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May 22, 1984

W65310.CO

EPA Region 5 Records Ctr.



253056

Mr. Don Bruce  
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U.S. Environmental Protection Agency  
230 South Dearborn Street  
13th Floor  
Chicago, Illinois 60604

Dear Don:

Subject: Chem-Dyne Hazardous Waste Site  
RI/FS  
WA 21.5M10.0  
Final Remedial Investigation (RI) Report

CH2M HILL, Inc., hereby submits the final Remedial Investigation (RI) report for the Chem-Dyne site in Hamilton, Ohio. Following interim final review, CH2M HILL prepared this submittal in final form. The submittal of this final RI report completes all requirements for remedial investigation in accordance with the final work plan.

As you requested, attached are three additional copies. Please contact me if there are any questions or comments regarding this final RI report.

Respectfully Submitted,

Larry A. Holm, P.E.  
Remedial Site Project Manager

nmf/GLT460/66  
Attachment

Mr. Don Bruce  
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Remedial Investigation Report  
Volume 1 of 2  
Chem-Dyne Site  
Hamilton, Ohio  
WA 21.5M10.0  
W65310.CO

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## Chapter 1 INTRODUCTION

This remedial investigation (RI) report for the Chem-Dyne site in Hamilton, Ohio, is prepared in partial satisfaction of Contract No. 68-01-6692, Work Assignment No. 21.5M10.0, and the Final Work Plan (July 1983), Task 1 through 7.

### PURPOSE OF THE REPORT

This RI report is based, in part, on data obtained during remedial investigation activities conducted from April through November 1983 at the Chem-Dyne site. These data and those from other sources are used to define the site problems, identify pathways and receptors, and determine the necessity for and extent of remedial actions at the site.

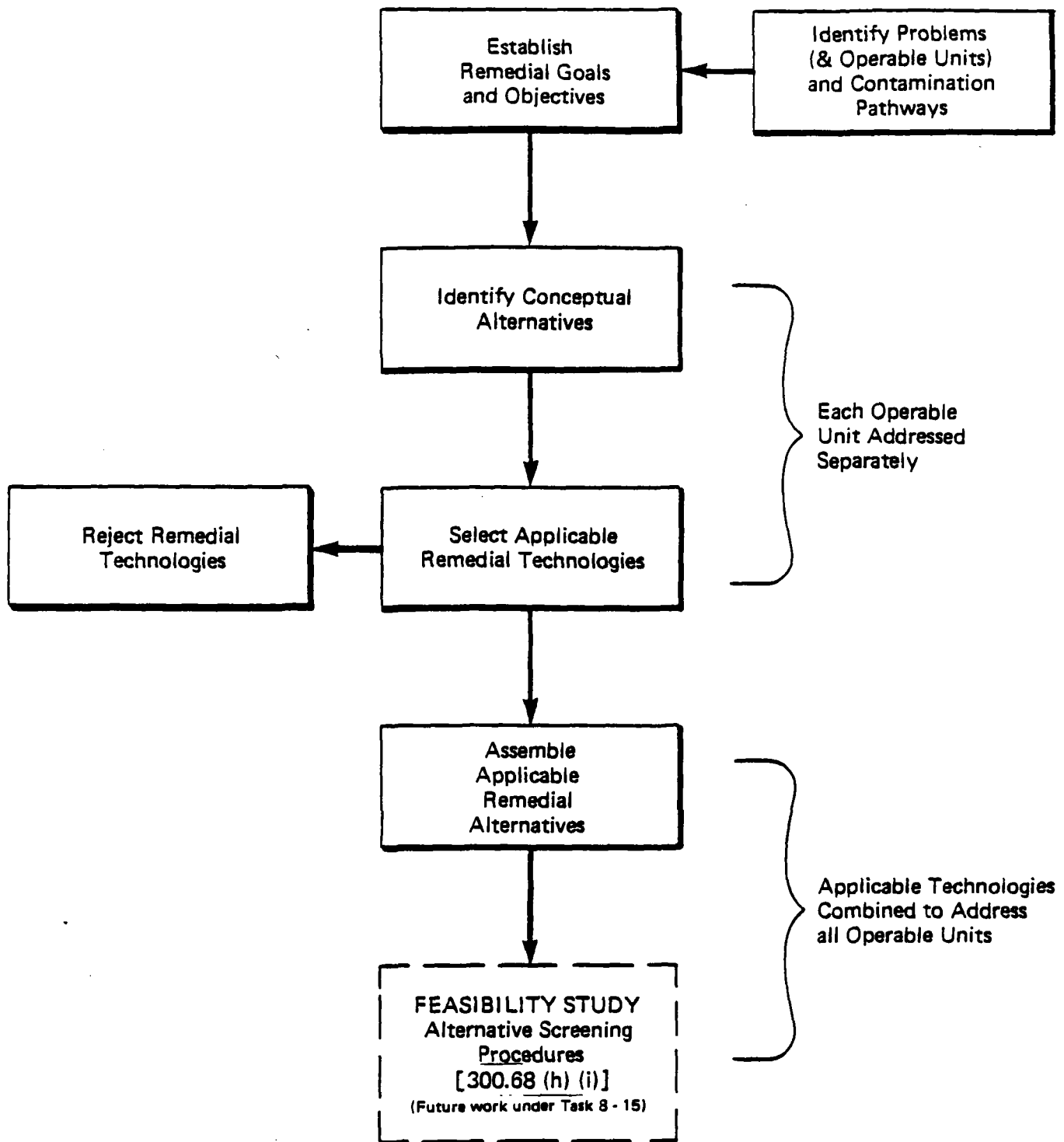
The purpose of this RI report is threefold: 1) Develop and describe applicable remedial alternatives; 2) Summarize and present the site investigation analyses and conclusions; and 3) Document the details of remedial investigation activities through technical memorandums in Volume 2 of 2.

### ORGANIZATION OF THE REPORT

This RI report is organized into three main sections. Chapter 2 presents the methodology and results of the development of applicable remedial alternatives. Chapter 3 presents the summary and conclusions of the investigation analyses. Volume 2 of 2 presents detailed documentation of activities and specific data obtained for each task (refer to the Final Work Plan, July 1983) completed during the remedial investigation.

### DEVELOPMENT OF APPLICABLE REMEDIAL ALTERNATIVES

Applicable remedial alternatives are developed following the approach shown in Figure 1. Guidance was taken from the National Contingency Plan (NCP) and the interim final Advanced Notification Preliminary Draft Interim Guidance on the Preparation of Feasibility Studies, dated September 29, 1983. To clearly understand the process, attention must be given to the terminology, especially "operable units", "conceptual alternatives," "remedial technologies," and "applicable remedial alternatives"; each is specifically defined below and represents a specific step in the development approach. Throughout this development, cost criteria are not applied to identification, selection, or rejection of applicable technologies; only technical feasibility and effectiveness are applied.



**FIGURE 1**  
**APPLICABLE REMEDIAL ALTERNATIVE**  
**DEVELOPMENT SCHEMATIC [300.68 (g)]**  
CHEM-DYNE RI REPORT

Operable units are defined to group site problems into specific areas of concern. For the Chem-Dyne site, the defined operable units include soil, groundwater, onsite facilities, and the Ford Canal. Pathways of contamination are the natural movement of contaminants from, within, and between operable units. The problems and pathways of contamination are receptor-oriented; each operable unit is considered in relation to potential receptors of contamination.

In general, the goal of every alternative is to mitigate and minimize damage to and provide adequate protection of public health, welfare, and the environment [40 CFR 300.68(j)].

Conceptual alternatives are general response actions that address site problems and pathways of contamination. These conceptual remedial alternatives are identified and carried forward for development into more detailed applicable remedial alternatives.

After conceptual alternatives are identified, applicable remedial technologies are selected using best engineering judgment for each alternative. These technologies are the specific techniques needed to implement each of the conceptual alternatives. Rejection of any remedial technology is based on three criteria:

- o physical site constraints
- o chemical or physical limitations
- o "proven" nature of the technology

The final step is the assembly of selected remedial technologies into applicable remedial alternatives. Due to the large number of potential assembled remedial alternatives, assembly of remedial alternatives will be performed during the feasibility study (to be conducted under Tasks 8 through 15).

#### ANALYSIS OF SITE INVESTIGATIONS

The analysis of site investigations conducted at Chem-Dyne from April through November 1983 is organized by the operable units. The analysis provides the technical basis for identification of problems and pathways of contamination for each operable unit.

#### RI ACTIVITY TECHNICAL MEMORANDUMS

Each remedial investigation activity is described in a technical memorandum (TM) issued during the course of RI work. These TM's are in Volume 2 of 2 of this report. Each TM describes specific procedures, observations, measurements, data results, etc., of RI activities.  
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## Chapter 2 DEVELOPMENT OF APPLICABLE REMEDIAL ALTERNATIVES

This chapter presents the development of applicable remedial alternatives to address defined problems at the Chem-Dyne site. Detailed supporting data, evaluations, and observations are presented in the next chapter, Analysis of Site Investigations.

This chapter is organized into five sections. Problems and pathways of contamination are summarized based on conclusions of the RI analysis (Chapter 3). Remedial goals and objectives are established consistent with the NCP. The identification, selection, and assembly processes for applicable remedial alternatives are discussed. Sets of applicable remedial alternatives which will initially be carried forward into the feasibility study are discussed. The final section is a summary of conclusions drawn from the site investigation analysis presented in the next chapter.

### PROBLEMS AND PATHWAYS OF CONTAMINATION

The problems at the Chem-Dyne site were identified using a receptor-oriented approach. Consistent with the NCP[300.68(c)], problems are identified according to the threat to the environment and/or human health and welfare.

Problems and pathways of contamination are arranged according to operable units. They are summarized in Table 1 and are discussed briefly in the following sections.

#### SOIL

The soil contamination problem has resulted from dumped or spilled chemical compounds on several areas of the site. The pathways of contamination are direct contact/carryover by site intruders (human and animal), air transport of volatiles and particulates, and leaching of compounds into groundwater and buried conduits onsite. Surface water runoff is also a potential pathway. However, considering the current topography at the site, significant flooding and runoff would be required for surface water transport of contaminated soil to offsite areas.

#### GROUNDWATER

Groundwater contamination is primarily caused by volatile organic compounds (VOC's). Although other contaminants are identified in groundwater from onsite wells, contaminants identified in groundwater from offsite wells are limited almost entirely to the volatile organic fraction. Because VOC's are the most widespread of the organic contaminants,

Table 1  
SUMMARY OF CHEM-DYNE PROBLEMS AND PATHWAYS OF CONTAMINATION

Operable Unit	Problem	Pathway of Contamination (Receptor)
Soil	Surface contamination	Direct skin contact (site intruders)
		Indirect contact by carryover (site intruders and their contacts)
		Leachate to saturated/unsaturated zone (groundwater consumer)
		Leachate infiltration to onsite conduits (receptors of stormwater drainage)
		Transmission by surface water runoff (receiving water local receptors)
	Subsurface contamination	Leachate to saturated/unsaturated zone (groundwater consumer)
	Volatile organic vapor air contamination	Inhalation of vapors (local receptors)
	Contaminated dust from site	Inhalation of airborne dust (local receptors)
Groundwater	Contamination with volatile organic compounds and movement of contaminated groundwater offsite	Natural movement of groundwater (potential future consumers/receiving water)
		Production well discharges (potential future consumers/receiving waters)
Onsite Facilities	Building contamination	Direct contact (site intruders and potential future demolition/developer personnel)
	Utility contamination	Direct contact (site intruders and potential future demolition/developer personnel)
		Infiltration discharge to Ford Canal from storm sewer (receiving water)
	Volatile organic vapor air contamination	Inhalation of vapors (local receptors)
	Contaminated dust from site	Inhalation of airborne dust (local receptors)
Ford Canal	Sediment contamination	Direct contact (people/animals)
		Leaching to canal water (receiving water)
		Indirect ingestion (fish consumers)
		Food chain bioaccumulation (biota)

the VOC's serve as indicators of the extent of the organic contamination of the groundwater system. Presently, there is no known direct contact with contaminated groundwater by groundwater consumers. Except at Champion Papers, VOC contamination was not detected in local production wells and there are no known private wells contaminated by groundwater; however, potential future receptors of contaminated groundwater are considered in identification of the problem. The potential for direct exposure of the greatest number of people is the potential of future VOC contamination of the City of Hamilton South Well Field that is approximately 4.7 miles south-southwest of the site.

Three volatile compounds, which are among the groundwater contaminants at the site, were identified at Champion Papers. It is possible that these compounds could be from sources other than the site.

Two pathways of contamination are considered. First, groundwater withdrawal (potential capture of all or portions of the contaminant plume(s)) by local production wells (nonpotable usage) at Mercy Hospital, the municipal power plant, and the Champion Paper Plant; second, groundwater movement to existing or future points of groundwater use or discharge, such as the City of Hamilton Municipal Well Field (potable water supply) and Great Miami River, caused by hydraulic and concentration gradients.

#### ONSITE FACILITIES

Contamination of the onsite buildings and utilities is caused by direct spillage and infiltration into buried utility conduits such as electrical conduits and storm sewers. Pathways of contamination are similar to onsite surface soils, i.e., direct contact by onsite intruders, air transport, infiltration into the storm sewers and into the Ford Canal. Receptors are the same as for soil and Ford Canal contamination.

#### FORD CANAL

The Ford Canal water, sediments, and fish were exposed to contaminants during site operation by discharges from the storm sewers draining the site. Based on the RI data, however, sediment contamination is the only present site-related problem concerning the canal. Pathways of contamination are limited to direct contact by humans or animals. Pathways such as direct contact and ingestion of water, ingestion of game fish and food chain bioaccumulation are not supported by current data. (Note: PCB's were found in fish tissues taken from the Ford Canal but the concentrations were similar to levels measured upstream of the site and, therefore, PCB's are not considered as

site-related contamination in fish tissues.) Receptors are shown in Table 1.

#### REMEDIAL GOALS AND OBJECTIVES

The general goal and objective of every remedial action is to "....mitigate(s) and minimize damage to and provide(s) adequate protection of public health, welfare, and the environment...." as specified in 40 CFR300.68(j).

Specifically, the following are remedial goals for the Chem-Dyne site:

- o Adequately protect against contact with contaminated soil.
- o Minimize damage to and provide adequate protection of the saturated zone from migrating soil contaminants.
- o Minimize damage from the adequately protect against the spread of contaminated groundwater.
- o Adequately protect against contact and ingestion or future contact and ingestion of contaminated groundwater.
- o Adequately protect against volatile organic and dust emissions into the air.
- o Adequately protect against contact with contaminated facilities.
- o Mitigate and minimize damage from and adequately protect against the discharge of contaminants from onsite storm sewers.
- o Adequately protect against contact with contaminated canal sediment.
- o Adequately protect against future contamination of the Ford Canal.
- o Adequately protect against future contamination of game fish in the Ford Canal and Great Miami River.

Each remedial goal is stated in terms of actions, including no action, that can be accomplished and not in terms of absolute removal, or restoration to pristine conditions. Instead, the goals reflect the NCP objectives to "mitigate and minimize damage" and "provide(s) adequate protection."

## CONCEPTUAL REMEDIAL ALTERNATIVES

Conceptual remedial alternatives in addition to the "no action" alternative were identified for each of the operable units. These conceptual alternatives are summarized in Table 2 and discussed briefly below.

### SOIL

The conceptual remedies for the problem of soil contamination address the pathways of direct contact, air transport, and leaching. Containment separates contamination from direct contact with receptors and eliminates transport of contaminants by air and percolating water. Removal and disposal accomplishes the same functions.

### GROUNDWATER

Several conceptual remedial actions, which provide adequate protection of the public against the contaminated groundwater, were identified. Containment, pumping, diversion, and treatment are all reasonable actions. Further screening during the feasibility study will be necessary to reduce the number of potential remedial alternatives to a manageable number.

### ONSITE FACILITIES

Conceptual remedial actions identified for the onsite buildings and utilities address the contamination pathways of direct receptor contact, air transport, and discharge from the storm sewer into the Ford Canal. The onsite buildings present an unusual but significant problem for remedial action because they are large and rather substantial. Decontamination, complete or partial demolition, and abandonment in place are reasonable actions.

Although demolition with complete removal and disposal is a major task, it is judged to be an alternative which requires consideration beyond this conceptual stage.

### FORD CANAL

Problems at the Ford Canal are, at present, indicated for sediments only. Elimination of storm sewer discharge from the site, discussed previously, would remedy the problem of continuing or future contamination of the canal. Therefore, sediment removal is the only conceptual alternative applied to the canal.

## APPLICABLE REMEDIAL TECHNOLOGIES

Table 3 provides a summary of the applicable remedial technologies selected to refine each conceptual alternative.

**Table 2**  
**SUMMARY OF SELECTED CONCEPTUAL REMEDIAL ALTERNATIVES**

<u>Operable Unit</u>	<u>Problem</u>	<u>Conceptual Remedial Alternatives</u>
Soil	Surface and air contamination Subsurface contamination Air contamination	Capping Containment Removal/disposal No action
Groundwater	Contamination with volatile organic compounds and movement of contaminated groundwater offsite	Capping Containment Pumping Onsite treatment/discharge Offsite treatment/discharge Direct Discharge No action
Onsite Facilities	Building contamination Utility contamination Air Contamination	Decontamination Complete demolition/removal/disposal Partial demolition/removal/disposal Complete abandonment No action
Ford Canal	Sediment contamination	Sediment removal/disposal No action

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Table 3  
SUMMARY OF APPLICABLE REMEDIAL TECHNOLOGIES

Operable Unit	Conceptual Alternative	Applicable Remedial Technologies
Soil	Capping	Sprayed asphalt membrane Concrete (bituminous or Portland cement) Multilayered systems Gravel over clay Soil over clay Soil over synthetic membrane Soil over clay over synthetic membrane
	Containment	Soil & bentonite slurry wall Cement & bentonite slurry wall Vibrating beam asphalt wall Grout curtain
	Complete or partial soil removal with disposal	Backhoe/loader/dragline Landfill
	Soil Treatment	Soil Washing
	No action	-
Groundwater	Capping	Sprayed asphalt membrane Concrete (bituminous or portland cement) Multilayered systems Gravel over clay Soil over clay Soil over synthetic membrane Soil over clay over synthetic membrane
	Containment (Vertical barriers downgradient, upgradient, or circumferential)	Soil & bentonite slurry wall Cement & bentonite slurry wall Vibrating beam asphalt wall Grout curtain
	Pumping	Drilled wells Extraction Extraction/injection
	Onsite treatment/discharge (private treatment facility)	Air stripping Steam stripping Carbon adsorption
	Offsite treatment/discharge (POTW)	Air stripping Biological adsorption/degradation Carbon adsorption (PACT)
	Direct discharge	Direct outfall Deep well injection
	No action	-
	No action	-
Onsite Facilities	Decontamination	Pressure steam wash
	Complete or partial demolition with disposal	Landfill
	Complete abandonment (utilities)	Grout seal Blind flange/cap seal
	No action	-
Ford Canal	Sediment removal with disposal	Hydraulic dredging Landfill
	No action	-

## TECHNICAL SELECTION CRITERIA

The criteria for selection or rejection of applicable remedial technologies are based on the following factors:

- o Data on physical site conditions that preclude, restrict, or promote the use of a specific technology
- o Chemical and physical characteristics of contamination that affect the effectiveness of a remedial technology
- o Inherent nature of a technology such as performance record, reliability, and operating problems

Construction and O&M costs are not criteria for selection of applicable remedial technologies. These costs will be considered along with other criteria during the feasibility study.

## APPLICABLE REMEDIAL TECHNOLOGY SELECTION

Based on engineering judgment, several remedial technologies appear to address site problems adequately. For example, seven different techniques and materials are applicable for construction of a site cap, and four options are applicable for vertical barriers. Because so many technologies survived this selection process, the individual applicable technologies will require further screening using additional criteria such as cost in the future feasibility study.

## REJECTED REMEDIAL TECHNOLOGIES

During the selection of applicable remedial technologies, several technologies and technology options were rejected. The rejected technologies are summarized in Table 4 with explanations for rejection.

## REMEDIAL ALTERNATIVE ASSEMBLY

### GENERAL REMEDIAL ACTIONS AND TECHNOLOGY OPTIONS

The final step in the development of applicable remedial alternatives is the assembly of alternatives using the selected applicable remedial technologies.

The selected technologies and all possible combinations are too numerous to use to manageably discriminate between applicable remedial alternatives. For example, the combination of cap and vertical barrier technologies alone results in 28 alternatives. Therefore, the applicable

Table 4  
SUMMARY OF REJECTED REMEDIAL TECHNOLOGIES

<u>Operable Unit</u>	<u>Conceptual Alternative</u>	<u>Rejected Remedial Technology</u>	<u>Explanation for Rejection</u>
Soil	Containment or capping	Chemical sealants/stabilizers	Freeze/thaw damage
	Soil treatment	Fly ash Landfarming	Wind and water erosion Contaminants generally not biodegradable
Groundwater	Capping	Chemical sealants/stabilizers	Freeze thaw damage
	Containment	Sheet pile wall	Rocks and cobbles
		Horizontal barriers (bottom sealing)	Heterogeneous geologic conditions
	Pumping	Injection wells (alone, without other groundwater controls)	Altered groundwater flow patterns unacceptable
		Well point systems	Construction impossible
		Ejector wells	Insufficient flow capacity
	Onsite treatment/discharge (private treatment)	Biological techniques	Contaminants not biodegradable
		Chemical techniques (except activated carbon)	Applicable to high concentrations or inorganics only. Oxidation rejected due to oxidation state of contaminants
		Physical techniques (except air and steam stripping)	Applicable to solids removal, oil separation, or sludge, only
Onsite Facilities	-	In situ techniques	Contaminants not biodegradable polymerizable, reactive, or subject to vitrification. Plume too large and deep for treatment beds.
		None	-
		-	-
Ford Canal	Partial sediment removal	Mechanical dredging	Canal flow too fast - fine carryout Pneumatic dredging Canal too shallow; generally not applicable to large area.
	Offsite disposal	Land farming	Contamination generally not biodegradable.

remedial alternatives will be assembled from general remedial actions and general technology options summarized in Table 3. The specific remedial technologies, e.g., types of capping or vertical barriers, will be assessed separately in the next step of the decisionmaking process, i.e., the feasibility study.

Eleven general remedial actions and technology options were selected to assemble remedial alternatives for further screening:

- o Capping (including grading and revegetation as required)
- o Soil washing
- o Soil removal
- o Downgradient vertical barriers
- o Circumferential vertical barriers
- o Upgradient vertical barriers
- o Extraction well pumping
- o Extraction/injection well pumping
- o Building and utility decontamination
- o Building and utility demolition
- o Complete facility abandonment
- o Partial sediment removal
- o No action

These general remedial actions address the site problems listed in Table 1. Individually, they address one or more problems but not every problem as shown in Table 5. Therefore, these general remedial actions must be used in appropriate combinations to be assembled into a reasonable number of remedial alternatives.

In addition to the general remedial actions and technology options listed above, contaminant treatment and disposal (applicable to soil, groundwater and sediment) are also identified in Table 3. Treatment and disposal alternatives are considered secondary alternatives because their requirement depends entirely on the primary remedial actions. For example, groundwater treatment and disposal is required only if an extraction pumping alternative is selected. These secondary remedial alternatives will be screened during the feasibility study.

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## ASSEMBLED APPLICABLE REMEDIAL ALTERNATIVES

The potential number of assembled remedial alternatives is extremely large and unmanageable when appropriate combination of the previously listed eleven general remedial actions are considered. The task of assembling remedial alternatives is further complicated by the large number of applicable technologies.

Due to the large number of potential assembled remedial alternatives, assembly of remedial alternatives will be performed during the feasibility study. In the feasibility study, technologies will be assessed and a reasonable number of remedial alternatives assembled.

## SUMMARY OF CONCLUSIONS FROM ANALYSIS OF SITE INVESTIGATIONS

- o Contamination of soil by inorganic and organic constituents appears greatest, in both frequency and concentration, in surface or near surface soil (approximately the upper 10 feet).
- o All areas sampled within the fenced perimeter of the site and one area outside (soil test pit TP-2) indicated soil contamination by organic compounds.
- o The distribution of surface soil contamination by inorganic constituents appears erratic, potentially due to isolated contamination events.
- o Primary organic soil contaminants include pesticides, base/neutral compounds, and volatile organic compounds.
- o Mobilities of organic and inorganic contaminants are uncertain due to complex and unknown interactions among factors affecting mobility, such as organic and inorganic constituents present, concentrations of soil constituents, percent soil organic matter, percent clay, and microbial activity.
- o Chemical analysis of samples collected from the blue warehouse parking lot and potential spillage during waste drum storage in the blue warehouse requires redefinition of the site boundaries to include these areas in addition to the already fenced area.
- o The results of the aquifer pump test provided a range of values for transmissivity and storage coefficients, from  $0.3 \times 10^5$  gpd/ft to  $7.0 \times 10^5$  gpd/ft for transmissivity and 0.0009 to 0.32 for storage coefficients. Most of the values for

transmissivity fall within a much narrower range of  $1 \times 10^5$  gpd/ft to  $3 \times 10^5$  gpd/ft. Higher values of transmissivity are generally toward the west and southwest.

- o Groundwater flow directions are across the site and downward from the area near well Nos. MW-1, MW-2, and MW-3 toward the west and southwest. Higher transmissivity values near the river and higher values of transmissivity parallel to the river may diver flow more toward the south. Conversely, strong vertical flow components and the impact of the Champion Paper Company's wells on the west side of the river indicate groundwater flow is moving to the west underneath the river. The direction of movement of the contaminated groundwater plume indicates westward and downward flow beneath the site and toward the Champion wells is the predominant direction of flow. However, the lack of sampling points in the southwest area and in the deeper portions of the aquifer do not allow the more southerly flow path to be evaluated in detail.
- o Rates of groundwater flow based on an assumed porosity (N) of 0.30, a gradient (I) of 0.002, and an average hydraulic conductivity (K) of 1,100 gpd/ft<sup>2</sup> or 147 ft/day are:  $V = KI/N = 0.98$  ft/day. If the porosity and gradient are assumed to be relatively constant the greatest range of groundwater velocities from 0.15 ft/day to 3.5 ft/day. Because of the limitations on the data from the pump test the upper and lower bounds for this range are suspect. The most reliable data indicate the range for groundwater velocities is between 0.5 ft/day to 1.5 ft/day.
- o The groundwater contamination plume is best defined by the extent of VOC's, many of which are relatively mobile and persistent. Within the plume, inorganics found in concentrations greater than Interim Primary Drinking Water Standards are barium, lead and mercury. The VOC plume has two distinct areas of very high concentrations relative to the overall plume. The apparent separation of the two areas of high concentration may be hydraulically induced (poor hydraulic connection) or may be related to separate sources of contamination.
- o Most of the VOC contamination appears to be in the upper 4 to 6 feet of the water table.

- o Locally VOC contamination has spread to depths of at least 65 feet in the aquifers.
- o Sample analysis demonstrated contamination of the Chem-Dyne buildings floor and contaminated seepage was observed in the basement of the boiler building. Reconnaissance, observations, and information concerning past waste handling practices at the site suggest potentially contaminated areas in the Ford building and the blue warehouse.
- o Direct contamination of the canal water as it passes the site is not demonstrated by the data.
- o Mercury concentrations were elevated in soil samples taken from the southern portion of the site (soil test pits TP-1, TP-2, TP-3, and TP-4), Ford Canal sediment collected downstream from the site, and infrequently in apparently random groundwater samples.
- o Storm sewer infiltration discharges very low concentrations of endrin to the Ford Canal.
- o Hazards are presented by the extreme structural distress of some buildings, particularly the Chem-Dyne and boiler buildings. The relative ease of access to the building interiors compound these hazards.

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### Chapter 3 ANALYSIS OF SITE INVESTIGATIONS

This chapter summarizes and analyzes the results of the remedial investigation (RI). Conclusions pertinent to the definition of site problems and pathways of contamination are drawn for each of the following operable units:

- o Soil
- o Groundwater
- o Onsite facilities
- o Ford Canal

The following discussions and summaries address each of the operable units. Although not specifically an operable unit, air contamination is addressed in a separate section of this chapter as it relates to the operable units.

Table 6 summarizes the sampling episodes per task in the RI. The results of the sampling and analytical work form the basis for most of the analyses and conclusions in this chapter. Detailed data are presented in the TM's in Volume 2 of 2 of this report.

#### SOIL

##### SITE GEOLOGY

During the RI several field efforts were conducted to provide supplemental information on geology at the site. Two phases of monitoring well installation, one onsite and the other offsite, allowed greater definition of the horizontal and vertical extent of unconsolidated materials present at the site. Excavation of thirteen soil sampling pits provided detailed information regarding the composition and variability of the near surface fill material found onsite.

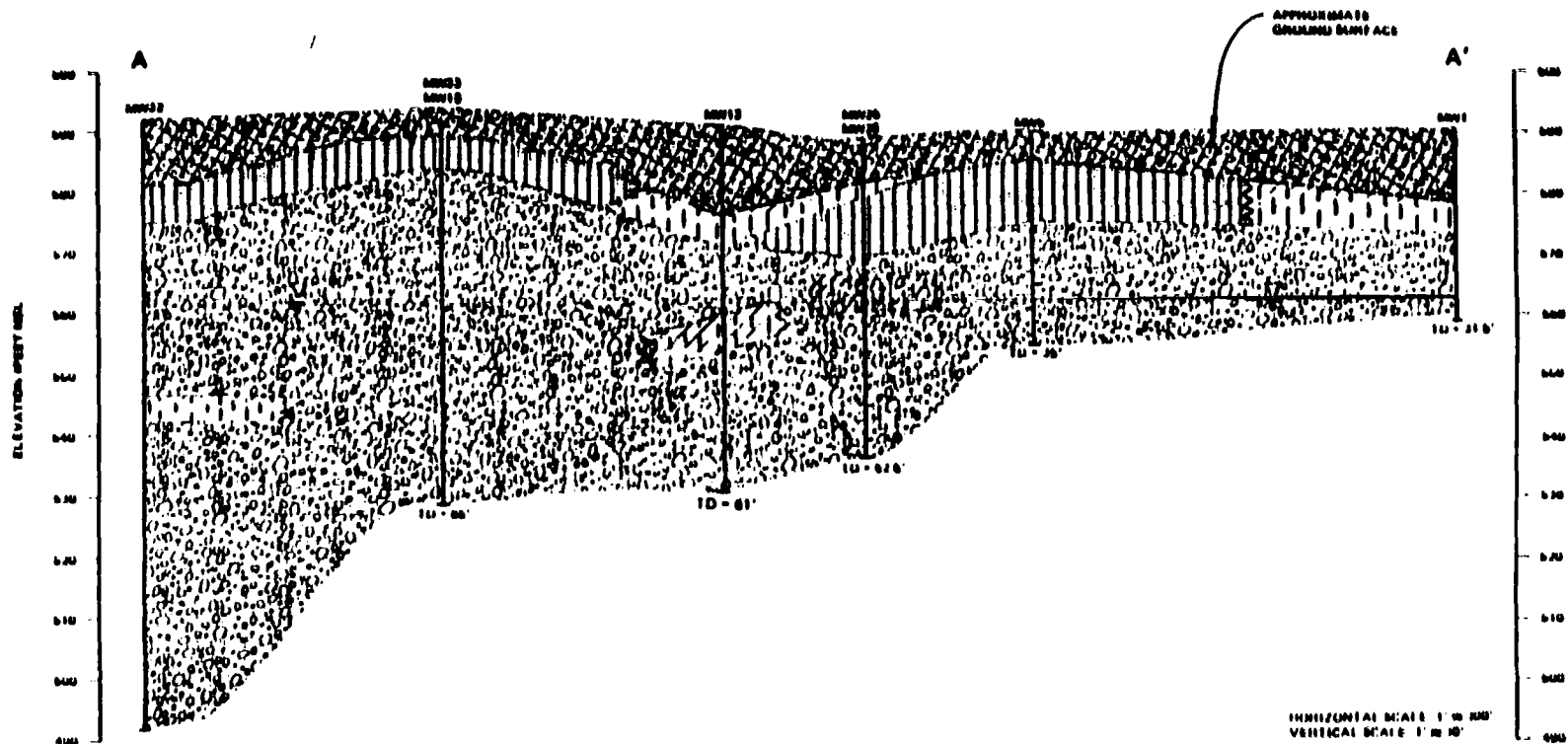
Cross-sectional views of the unconsolidated materials encountered at the site are presented in Figures 2a through 2d. These views are generalized from and interpolated between soil borings performed during the Field Investigation Team (FIT) and Roy F. Weston investigations, together with drilling and soil borings conducted during the RI (boring logs developed during the Roy F. Weston investigation and RI are presented in TM's for Task 1, Subtask 3-2.2, and Subtask 3-3.2 attached in Volume 2 of 2). The general stratigraphy of the unconsolidated materials shown in the cross-sectional views is consistent with the description included in the FIT Investigation Report. However, the drilling performed during the RI provided

Table 6  
SUMMARY OF REMEDIAL INVESTIGATION SAMPLING AND ANALYSIS EFFORTS

<u>Task/Subtask</u>	<u>Sample Description</u>	<u>Sampling Period</u>	<u>Case or SAS Number</u>
3-1	Phase I Groundwater, Soil and Canal 22 Groundwater 1 Surface water 3 Sediments 10 Onsite soil 4 Offsite soil	April 1983	1608
3-1	Phase I Soil 6 Onsite soil for dioxin	April 1983	SAS 494E
3-2.3	Phase II Soil 22 Splitspoon soils	May 1983	1746
3-2.4	Phase II Groundwater 36 Groundwater	June 1983 July 1983	1746 1878
3-2.5	Phase II Canal 4 Surface Water 8 Sediment	Sept. 1983	1964
3-2.5	Phase II Canal 28 Fish Tissues	Sept. 1983	SAS 736E
3-3.3	Phase III Groundwater 45 Groundwater	Oct. 1983	2064
3-4	Final Soils Investigation 50 Test Pit Soils	Aug. 1983	1964
3-4	Final Soils Investigation 10 Test Pit Soils	Aug. 1983	SAS 735E



FIGURE 2A  
CROSS - SECTION  
TRANSECTS  
CHEM - DYNE RI



#### LEGEND

- FILL (SILTY SAND TO SANDY GRAVEL)
- CLAYEY SILT TO SILTY CLAY
- SILTY SAND
- SANDY GRAVEL TO GRAVELLY SAND
- SAND
- CLAYEY GRAVEL
- CLAYEY SILTY SAND
- GRAVELLY SILTY CLAY, CLAYEY SILT WITH SAND AND GRAVEL

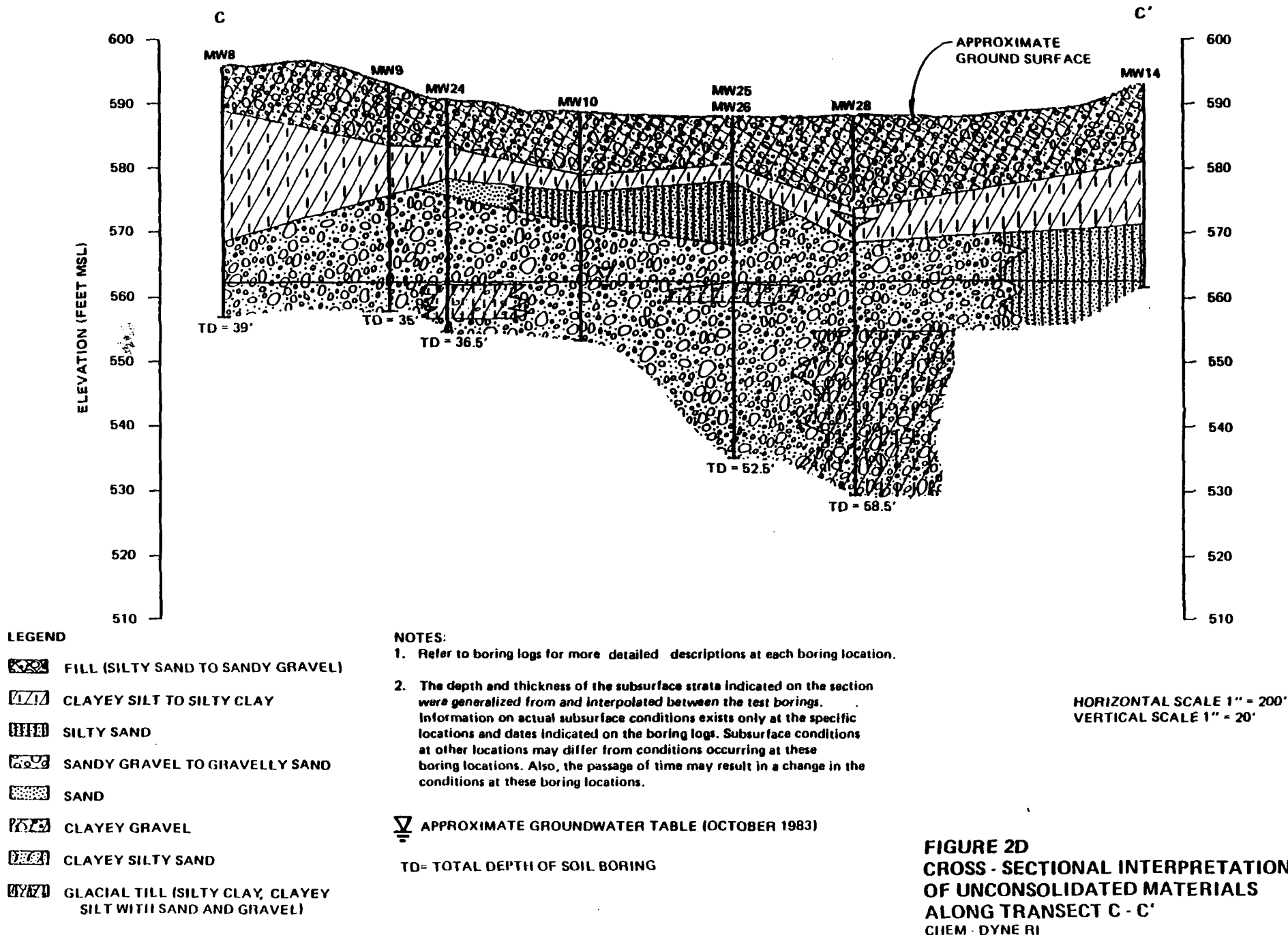
#### NOTES

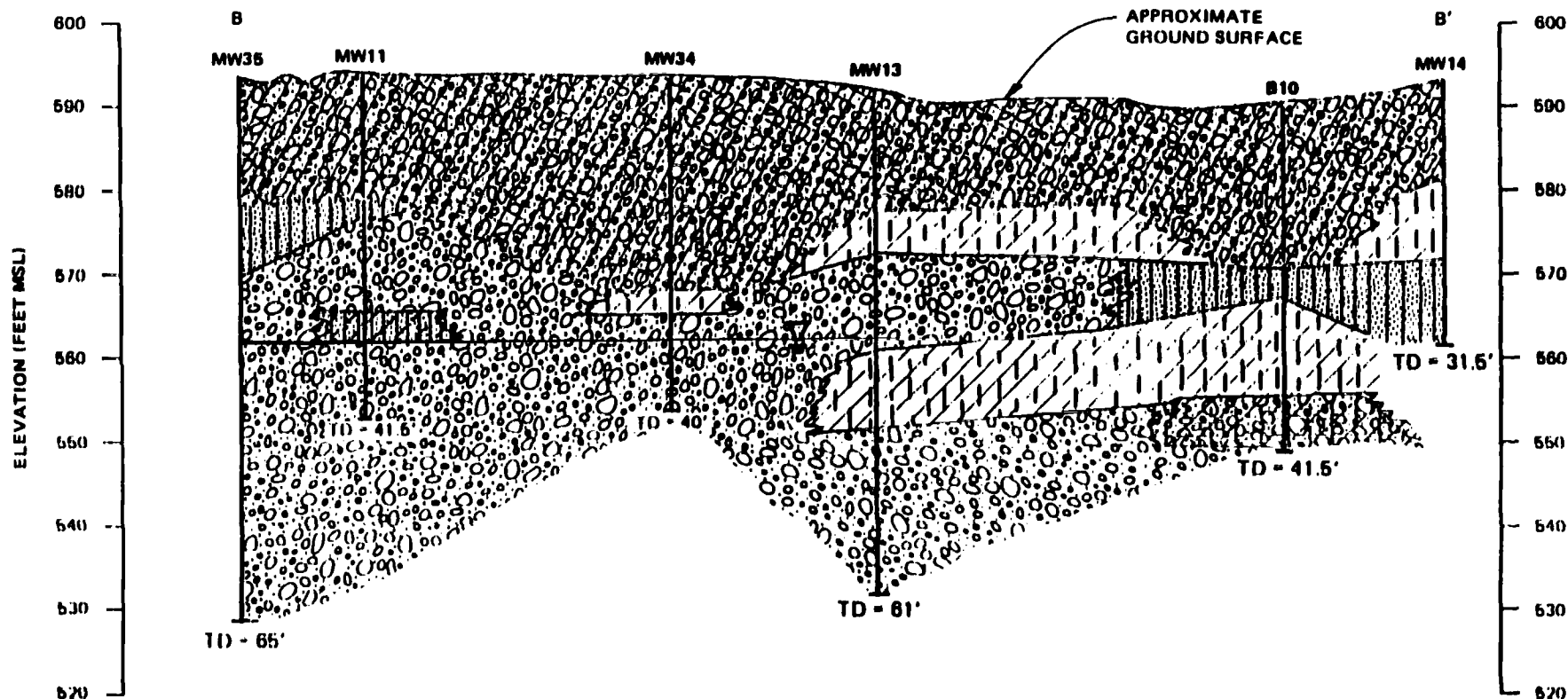
1. Refer to boring logs for more detailed descriptions of each boring location.
2. The depth and thickness of the subsurface strata indicated on the section were generated from and interpolated between the test borings. Information on actual subsurface conditions exists only at the specific locations and dates indicated on the boring logs. Subsurface conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the conditions at these boring locations.

APPROXIMATE GROUNDWATER TABLE (N.T. 100.0)

TD - TOTAL DEPTH OF SOIL BORING

**FIGURE 2B**  
**CROSS-SECTIONAL INTERPRETATION**  
**OF UNCONSOLIDATED MATERIALS**  
**ALONG TRANSECT A - A'**  
 CHEM - DYNE III





#### LEGEND

- TILL (SILTY SAND TO SANDY GRAVEL)
- CLAYEY SILT TO SILTY CLAY
- SILTY SAND
- SANDY GRAVEL TO GRAVELLY SAND
- SAND
- CLAYEY GRAVEL
- CLAYEY SILTY SAND
- GLACIAL TILL (SILTY CLAY, CLAYEY SILT WITH SAND AND GRAVEL)

#### NOTES

1. Refer to boring logs for more detailed descriptions at each boring location.
2. The depth and thickness of the subsurface strata indicated on the section were generalized from and interpolated between the test borings. Information on actual subsurface conditions exists only at the specific locations and dates indicated on the boring logs. Subsurface conditions at other locations may differ from conditions occurring at these boring locations. Also, the passage of time may result in a change in the conditions at these boring locations.



APPROXIMATE GROUNDWATER TABLE (OCTOBER 1983)

TD = TOTAL DEPTH OF SOIL BORING

HORIZONTAL SCALE 1" = 200'  
VERTICAL SCALE 1" = 20'

**FIGURE 2C**  
**CROSS-SECTIONAL INTERPRETATION**  
**OF UNCONSOLIDATED MATERIALS**  
**ALONG TRANSECT B-B'**  
CH2M - DYNE N

valuable additional observations concerning the lateral extent and variability of the deposits. Often borings conducted adjacent to one another showed as poor a correlation in stratigraphic and lithologic features as did borings separated by large distances. It is important to keep this extreme variability in mind, when viewing the cross-sections presented on Figures 2B through 2D.

Fill, placed during the development of the area for the Ford plant in the early 1900's, caps the sequence of unconsolidated deposits at the site. The fill is generally a brown, gravelly or silty sand with locally variable amounts of rubble. Excavated pits indicate the fill onsite is extremely variable in composition, with horizons of brick, timber, ashy material, and miscellaneous rubbish commonly present within several feet of the ground surface. Generally, the fill is underlain by an interfingered brown-gray silt and brown silty sand. This interbedded unit of silt and silty sand appears laterally extensive in the vicinity of the site. The brown silty sand grades into a coarse sandy gravel containing lenses of finer material, including glacial till. In the vicinity of Hamilton, the sandy gravel is underlain by a deposit of blue-gray silt and greenish sandy silty clay. This once thick and extensive deposit of silt and clay, has been considerably thinned and dissected by fluvial processes in the vicinity of the site. Beneath this horizon of silt and clay, a sequence of sand, gravel, and coarser material extends over 150 feet to bedrock.

Drilling performed during the RI provided valuable information on the local variability of unconsolidated materials at the site. In particular, the interpretation of the lateral distribution of the gray silt/greenish clay deposit in the vicinity of the site was refined. This deposit appears to significantly influence groundwater levels and flow which in turn affects contaminant migration and applicability of remedial technologies. Industrial well logs and deep borings west of and adjacent to the Great Miami River suggest this gray silt/greenish clay deposit is continuous beneath and to the west of the river. Soil borings performed during the RI indicate this deposit is present east of the river as relatively thin, scattered and localized remnants. West of the site, fluvial processes have apparently eroded the deposit completely in the vicinity of monitoring wells MW-35, MW-11, MW-34, MW-33, and MW-31. Also, the deposit is apparently absent directly beneath and east of the site. In areas where this gray silt/greenish clay deposit has been eroded, channel deposits of sand and gravel have been deposited providing a sand and gravel sequence to depth. Figure 3 presents an interpretation of the lateral distribution of the gray silt/



FIGURE 3  
APPARENT LATERAL  
DISTRIBUTION OF GRAY SILT/  
GREENISH CLAY DEPOSIT AT  
THE CHEM - DYNE SITE  
CHEM - DYNE RI

greenish clay deposit based on data obtained during the RI and from prior investigations.

## CHEMICAL ANALYSIS DISCUSSION

### Scope of Soil Sampling and Analysis

During the RI, soil sampling was conducted in three episodes. The first sampling effort (Phase I) in April 1983 included 14 surface soil samples collected from both inside and outside the fenced perimeter of the site. The second sampling effort (Phase II) in May-June 1983 involved collection of split spoon soil samples from seven soil borings onsite. The Final Soil Investigation effort in August 1983 completed RI soil sampling activities and included 7 surface soil samples and samples collected from 13 pits excavated inside and outside the fenced perimeter of the site. Soil sampling locations are presented in Figures 4 through 6.

Chemical analysis of soil samples collected during the RI consisted of the following:

- o Routine inorganic analysis package, including cyanide from the U.S. EPA contract laboratory program (CLP).
- o Routine organic analysis package from the U.S. EPA CLP.

In addition, six surface soil samples from April and 10 soil samples taken during the Final Soil Investigation effort were analyzed for dioxin. The 10 soil samples from the final soil investigation effort were also analyzed for tris(2,3-dibromopropyl)phosphate (tris), polybrominated biphenols (PBB), and curene-442 using the special analytical services (SAS) program of the U.S. EPA CLP.

### Inorganic Contamination

Evaluation of inorganic contamination was made by comparison of the analytical results from offsite samples (OS-1 and OS-2) with the remaining soil samples. Soil samples OS-1 and 2 were taken from locations outside the fenced perimeter of the site and represent soil unaffected by Chem-Dyne operations. Soil samples OS-3 and OS-4 were not designated as background samples because of their proximity to previous waste storage and the relatively high concentrations of tin and antimony measured in sample OS-3. For discussion and comparison purposes in this report, soil samples are considered to have "significantly high concentrations" of a particular element, if those concentrations exceeded the

concentration observed in the unaffected soil samples by at least an order of magnitude (10 times).

Analytical data from each soil sample are summarized in Figures 7 through 9. In these figures, inorganic constituents with similar concentration ranges were grouped for comparison purposes to avoid masking of minor constituent variations. The inorganic constituents were grouped as follows:

- o aluminum, iron, manganese
- o barium, copper, lead, zinc
- o arsenic, boron, chromium, cobalt, nickel, vanadium
- o antimony, beryllium, cadmium, cyanide, mercury, selenium, silver, thallium, tin

Figure 7 presents analytical data for surface soil samples. Figures 8 and 9 present analytical data from split spoon and test pit samples, reflecting the subsurface distribution of those samples. A review of these summary figures and the analysis data, presented in Volume 2 of 2 (TM's regarding the Phase I and Phase II Hydrogeological Investigations and the Final Soil Investigation), indicate a number of soil samples contained significant concentrations of inorganic constituents.

Elements present in soil samples at significantly high concentrations are shown in Table 7, along with maximum concentrations reported. For the majority of the elements listed in Table 7, significantly high concentrations were associated with surface or near surface soil. The distribution and frequency of these high concentration samples appears random and may be associated with infrequent and localized contamination events. Subsurface soil contamination is primarily limited to tin and mercury and appears limited to the south and south eastern portions of the site. Soil sampling pits 1, 2, 3, and 4 contain samples with significantly high concentrations of tin and mercury to depths of 8 feet.

Accepted standards are not available for evaluating the potential hazards of public exposure to soil containing inorganic concentrations as shown in Table 7.

#### Organic Contamination

Samples OS-1 and OS-2 were collected in areas unaffected by Chem-Dyne operations. Priority pollutant organic compounds were absent in these two samples, except for a 84 ug/kg of methylene chloride detected in sample OS-2 and relatively small amounts of dieldrin, chlordane, 4,4'-DDE, and 4,4'-DDT (all concentrations, except chlordane at 1,000/ug/kg, were less than 100 ug/kg). Therefore, during this discussion the presence of a priority pollutant organic compound, or in

Table 7  
SUMMARY OF ELEMENTS PRESENT IN SOIL SAMPLES AT  
SIGNIFICANTLY HIGH CONCENTRATIONS  
CHEM-DYNE RI REPORT (W65310.C0)

<u>Element</u>	<u>Sample Locations</u>	<u>Maximum Concentration (mg/kg)</u>
Antimony	OS(3); SS(6,7)	390(OS-3) <sup>a</sup>
Arsenic	SS(5,6,10); TP(1-3)	100(SS-10)
Beryllium	SS(2)	700(SS-2)
Chromium	SS(7,8)	250(SS-7)
Copper	SS(2); TP(3-4, 4-3, 10-3)	785(TP-3-4)
Lead	SS(6,7,8); TP(4-3, 6-1, 9-2, 13-4)	11,900(TP-4-3)
Mercury	TP(1 through 4, 11-1) <sup>b</sup>	8.15(TP-11-1)
Nickel	GS(2)	1,020(GS-2)
Tin	OS(3); SS(4,5,6,7,8); TP (1 through 4, 9-2, 13-2, 13-3) <sup>b</sup>	12,000(OS-3)
Zinc	TP(7-1)	1,240(TP-7-1)

<sup>a</sup>Sample location associated with maximum concentration enclosed in parenthesis.

<sup>b</sup>TP(1 through 4) denotes all soil samples analyzed from soil test pits 1, 2, 3 and 4.

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the case of methylene chloride and the above-mentioned pesticides, their presence in greater than previously identified amounts in a soil sample is considered contamination.

Analytical data demonstrate that soil at the Chem-Dyne site is contaminated with organic compounds, primarily base/neutral (B/N's), volatile organic compounds (VOC's), and pesticides.

Figures 10 through 12 summarize portions of the organic analytical data from soil samples taken at the Chem-Dyne site. These figures present bar diagrams which plot total B/N's and VOC's for each sample. The concentration magnitude of organic contamination in surface soil is shown in Figure 10. Variations in B/N's and VOC's contamination with depth are presented in Figures 11 and 12.

To more completely evaluate the organic analytical data, each major fraction of priority pollutant compounds was considered. The goals of this evaluation included the following:

- o Identify compounds that constitute the majority of soil contamination
- o Identify compounds that are carcinogenic, exceptionally toxic, and/or persistent

Acid Compounds. Five acid fraction priority pollutant organic compounds were identified. Compounds identified were p-chloro-m-cresol (4-chloro-3-methylphenol), 2-chlorophenol, 4-nitrophenol, pentachlorophenol, and phenol. Contamination with these compounds was limited entirely, with the exception of phenol, to one split spoon sample (SS-13 collected at a depth of 35 feet) in soil boring MW-29. Phenol was identified in four other soil samples (TP-6-4, TP-10-4, SS-4, and OS-3). In all soil samples individual compound concentrations were less than 5,000 ug/kg and in most instances less than 1,000 ug/kg.

The restricted occurrence of these compounds suggests limited and localized contamination. With the exception of pentachlorophenol, these compounds are relatively nonpersistent and not particularly toxic. Pentachlorophenol is highly persistent and associated with wood preservative wastes.

Base/Neutral Compounds (B/N's). A wide assortment of B/N's were identified. Review of the analytical data presented in Figures 10 through 12 suggests B/N contamination is widespread onsite. The occurrence of B/N compounds in soil samples from the site are summarized in Table 8.

**Table 8**  
**SUMMARY OF THE OCCURRENCE OF B/N COMPOUNDS IN SOIL SAMPLES - CHEM-DYNE RI**

<u>Compound</u>	<u>Phase I</u> <u>Surface Soil Samples</u>	<u>Phase II</u> <u>Split Spoon Samples</u>	<u>Final Soil Investigation</u> <u>Test Pit Samples</u>
Hexachlorobenzene	SS(2,4,7,8,9,10)		
1,2-Dichlorobenzene	SS(7,8,10)		TP(8-2,8-3,8-6,8-7,9-2,10-1,10-2,10-3, 10-4,12-1,13-2,13-3,13-4)
1,3-Dichlorobenzene	SS(8)		TP(7-3,8-2,8-3,8-6,8-7,9-2,9-5,10-1,10-2, 10-3,10-4,12-1,13-2,13-3,13-4)
1,4-Dichlorobenzene	SS(8,10)		TP(7-1,8-2,8-6,10-1,10-2,10-3,10-4,13-2, 13-3,13-4)
Trichlorobenzene	SS(8,10)		
Hexachloroethane	SS(2,7,8,10)	(MW-27;SS-12)	TP(7-1,13-3,13-4)
Hexachlorobutadiene	SS(2,8,10)		
Benzo (a) anthracene	SS(3,9,10)	(MW-25;SS-3)	TP(2-5,3-3,3-4,8-2,10-2,10-4,11-4)
Benzo (a) pyrene	SS(3,9)	(MW-25;SS-3)	TP(3-4,10-2)
Benzo (b) fluoranthene	SS(3,9)	(MW-25;SS-3)	TP(3-4,10-2)
Benzo (k) fluoranthene	SS(3,9)	(MW-25;SS-3)	TP(3-4,6-4,10-2)
Benzo (ghi) perylene		(MW-25;SS-3)	TP(3-4)
Chrysene	SS(1,3,9,10)	(MW-25;SS-3)	TP(2-5,3-3,3-4,4-2,6-4,8-2,10-2,10-4, 11-4)
Anthracene		(MW-25;SS-3)	TP(10-2)
Fluoranthene	SS(1,3,9,10)	(MW-25;SS-3)(MW-26;SS-7)(MW-29;SS-13)	TP(1-1,2-2,2-5,3-3,3-4,6-4,8-2,10-2,10-4, 11-4)
Pyrene	SS(1,3,9,10)	(MW-25;SS-3)(MW-26;SS-7)(MW-29;SS-13)	TP(2-2,2-5,3-3,3-4,4-2,4-3,6-4,8-2,10-2, 10-4,11-1)
Phenanthrene	SS(1,3,9,10)	(MW-25;SS-3)(MW-26;SS-7,SS-11)(MW-29;SS-13)	TP(2-5,3-3,3-4,4-2,6-4,7-3,8-2,9-2,10-2, 10-4,11-4)
Naphthalene	SS(1,3,7,10)	(MW-25;SS-3)(MW-26;SS-11)	TP(3-4,4-2,6-4,8-2,9-2,12-1)
Acenaphthene		(MW-25;SS-3)	
Fluorene		(MW-25;SS-3)	
Indeno(1,2,3-cd)pyrene GLT447/15-1		(MW-25;SS-3)	

Table 8 (continued)

<u>Compound</u>	<u>Phase I</u> <u>Surface Soil Samples</u>	<u>Phase II</u> <u>Split Spoon Samples</u>	<u>Final Soil Investigation</u> <u>Test Pit Samples</u>
Bis(2-ethylhexyl)phthalate	SS(1,2,4,5,6,7,8,9,10)	(MW-23;SS-4,SS-8,SS-10)(MW-27;SS-12) (MW-28;SS-2)(MW-29;SS-7,SS-13)	TP(6-4,7-1,7-2,7-5,11-1,11-4)
Di-n-octyl phthalate	SS(3,7,8)	(MW-28;SS-2)	TP(7-5)
Di-n-butyl phthalate	SS(7)	(MW-28;SS-2)	TP(6-4,7-1,7-3,7-5,11-1)
Di-iso-butyl phthalate			
Diethyl phthalate			TP(2-2,3-1)
Dimethyl phthalate	SS(7)		
Bis(2-chloroethyl)ether			TP(11-1)
Isophorone	SS(8)	(MW-23;SS-4,SS-8,SS-10)	
Hexachlorocyclopentadiene	SS(2,9)		

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Compounds that appear relatively widespread and are generally present in elevated concentrations include the following:

hexachlorobenzene	benzo(a)anthracene
hexachloroethane	benzo(a)pyrene
1,2-dichlorobenzene	benzo(b)fluoranthene
1,3-dichlorobenzene	chrysene
1,4-dichlorobenzene	anthracene
bis(2-ethylhexyl)phthalate	fluoranthene
di-n-octyl phthalate	pyrene

The majority of soil samples collected at the site indicated contamination with B/N compounds. Total concentrations of B/N compounds ranged up to 70,000 ug/kg. The magnitude of contamination appears to decrease with increasing depth as indicated by the infrequent detection of B/N contaminants below a depth of approximately 10 feet. This observation generally agrees with FIT investigation findings in 1981.

Of the B/N compounds detected in soil at the site, three are identified carcinogens (National Toxicology Program 1982) and twelve are suspected carcinogens (Soderman, 1982). Known and suspected carcinogens B/N compounds detected in soil at the site are presented in Table 9.

The B/N compounds detected at the site are generally degradable. However, compounds considered highly persistent (resistant to biodegradation) in the NCP (40 CFR Part 300, Table 5) include the following:

benzo(a)pyrene	hexachloroethane
trichlorobenzene	di-N-butyl phthalate
hexachlorobenzene	bis(2-ethylhexyl) phthalate
1,4-dichlorobenzene	benzo butyl phthalte

Quantitative evaluation of degradation rates is beyond the scope of this discussion due to the limited scientific information concerning the B/N compounds, and potential interactions among other organic compounds and microorganisms present in soil at the site. In addition, quantitative evaluation of the mobility of these B/N compounds is not possible due to the complex interaction of influencing factors such as soil organic matter content, soil clay content and mineralogy, and other chemical contaminants present.

Volatile Organic Compounds (VOC's). Soil contamination by a wide assortment of VOC's was demonstrated by the analytical data. A review of the analytical data summarized and presented in Figures 10 through 12 suggest VOC contamination

Table 9  
 KNOWN AND SUSPECTED CARCINOGENIC BASE/NEUTRAL COMPOUNDS  
 DETECTED IN SOIL AT THE CHEM-DYNE SITE

Known Carcinogen <sup>a</sup>	Suspected Carcinogen <sup>b</sup>
benzo(a)anthracene	indeno(1,2,3-cd) pyrene
benzo(b)flouranthene	naphthalene
benzo(a)pyrene	n-nitrosodiphenylamine <sup>c</sup>
	phenanthrene
	pyrene
	acenaphthene
	anthracene
	benzo(k) flouranthene
	benzo(ghi) perylene
	bis(2-chloroethyl) ether
	chrysene
	flouranthene
	hexachloroethane
	3,3'-dichlorobenzidine <sup>c</sup>

<sup>a</sup>National Toxicology Program, 1982(2).

<sup>b</sup>Soderman, 1982(4).

<sup>c</sup>The occurrence of these compounds is restricted to grab samples (GS) and is discussed in the section concerning facilities.

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is widespread onsite. The occurrence of VOC's in soil samples from the is summarized in Table 10.

Nineteen priority pollutant VOC's were identified. Most frequently identified VOC's include the following:

benzene	trans-dichloroethene
toluene	tetrachloroethene
chlorobenzene	trichloroethene
1,1-dichloroethane	vinyl chloride
trichloroethanes (1,1,1 and 1,1,2)	methylene chloride
	ethylbenzene

Volatile organic compounds are present in onsite soil at cumulative concentrations of up to 12,000 ug/kg. However, most soil contaminated with VOC's contains less than 1000 ug/kg total VOC's.

Organic analysis data indicate that soil in the northern portions of the site is generally contaminated with greater concentrations of VOC's and a wider variety of VOC's than southern portions. In addition, analytical data indicate concentrations of VOC soil contamination are generally greater in surface and near-surface samples and decrease with increasing depth. However, samples taken in soil borings MW-24, MW-23, MW-27, and to a lesser extent MW-29, indicate concentrations of VOC soil contaminants again increase near the surface of the saturated zone. Analytical data collected during the FIT investigation does not appear to support this observation. Both RI and FIT data indicate VOC soil contamination is distributed throughout the fenced portion of the site.

Known and suspected carcinogenic VOC compounds identified in soil at the site are as follows:

Known Carcinogen (National  
Toxicology Program)

benzene  
carbon tetrachloride  
chloroform  
1,2-dichloroethane  
vinyl chloride

Suspected Carcinogen  
(Soderman)

chlorobenzene  
1,1,2,2-tetrachloroethane  
trans-dichloroethane

Table 10  
SUMMARY OF THE OCCURRENCE OF VOC'S IN SOIL SAMPLES - CHEN-DYNE RI

Compound	Phase I Surface Soil Samples	Phase II Split Spoon Samples	Final Soil Investigation Test Pit Samples
Benzene	SS(7,8)		TP(5-1,6-3,6-4,8-2,9-2)
Chlorobenzene	SS(7,8,10)		TP(5-3,7-1,7-3,9-2,9-5,10-1,10-2,10-3,10-4,11-1, 11-2,11-4,12-1)
1,1-Dichloroethane			TP(6-1,6-3,6-4,7-1,7-2,8-2,8-3,8-6,9-2,9-3,9-5, 10-1,10-2,10-3)
1,2-Dichloroethane	SS(6,7)	(MW-27,SS-5)	TP(11-2,11-3)
1,1,1-Trichloroethane	SS(6,7)		
1,1,2-Trichloroethane	SS(6,7,8,9,10)	(MW-23,SS-10)(MW-24,SS-11)(MW-25,SS-1)	TP(7-3,7-5,11-4,12-1,12-3,11-2,11-3,11-4)
Tetrachloroethane	SS(7,4,5,6,7,8,9,10)	(MW-27,SS-6,SS-12)	TP(7-3,7-5,8-2,8-3,8-6,8-7,9-1,9-5,10-1,10-3,11-1, 11-2,11-4,12-1,12-3,11-2,11-3,11-4)
1,2-Dichloropropane	SS(6)		
Bromochloromethane	SS(7)		
Fluorotrichloromethane		(MW-23,SS-4)(MW-25,SS-1)	
Chloroform	SS(6,7)	(MW-23,SS-10)(MW-24,SS-11)	
Methylene Chloride	SS(7)		TP(all samples except: 4-6,7-1,7-2,8-2,9-5,11-1, 11-2,12-1,11-3)
Toluene	SS(5,6,7,10)	(MW-23,SS-10)	TP(1-1,2-2,2-4,2-5,3-5,4-2,4-3,5-1,6-3,6-4,7-3,8-2, 8-6,9-2,10-1,10-3,10-4,11-1,11-2,11-4)
Ethyl Benzene	SS(7)	(MW-26,SS-11)(MW-27,SS-6)	
Carbon Tetrachloride		(MW-23,SS-10)(MW-24,SS-11)	
1,1-Dichloroethene	SS(7,8,10)		TP(9-2)
Trans-dichloroethene		(MW-23,SS-10)(MW-27,SS-5)	TP(5-1,6-1,6-3,6-4,9-2,10-4,11-4)
Trichloroethene	SS(2,4,6,7,8,10)	(MW-23,SS-10)(MW-24,SS-11) (MW-25,SS-1)(MW-27,SS-12)	TP(5-1,5-3,6-1,6-3,6-4,7-5,8-2,9-2,10-4,11-4,11-2, 11-4)
Tetrachloroethene	SS(2,3,4,5,6,7,8,9,10)	(MW-23,SS-4,SS-10)(MW-25,SS-3,SS-6) (MW-26,SS-7)(MW-27,SS-5,SS-6,SS-12)	TP(5-1,5-3,6-1,6-3,6-4,7-1,7-2,7-3,8-2,8-6,9-2, 10-1,10-3,10-4,11-1,11-2,12-3,11-3,11-4)
Vinyl Chloride			TP(6-4,9-3)

The relative persistence (resistance to biodegradation of several VOC's identified in soil samples from the site, including known and suspected carcinogens, are presented in Table 11.

Pesticides Compounds. Analytical data indicate pesticide contamination of soil at the site. Pesticide compounds detected, sample locations containing pesticides, and maximum concentrations reported are presented in Table 12.

The distribution of pesticide contamination appears primarily limited to the eastern (in the vicinity of sampling test pit TP-7) and the northwestern (in the vicinity of the loading dock and Chem-Dyne building) areas of the site. The data also suggest contamination of soil in the coal bin at the north end of the site. Analytical data reported from the FIT Investigation agree well with data from the RI sampling.

The generally strong affinity of these pesticides for adsorption to soil particles may explain their limited soil penetration. Pesticide contamination is primarily restricted to near-surface soil. Many of the pesticides present in soil at the site, such as aldrin, chlordane, DDE, DDT, dieldrin, endrin, heptachlor, and PCB, are classified as highly persistent compounds by the NCP (40 CFR, Part 300, Table 5). Several of the pesticide compounds, identified in soil at the site and classified as highly persistent by the NCP, are known or suspected carcinogens. Known and suspected carcinogenic pesticide compounds identified in soil at the site include the following:

<u>Known Carcinogen (National Toxicology Program)</u>	<u>Suspected Carcinogen (Soderman)</u>
g-BHC (lindane) PCB	dieldrin heptachlor heptachlor epoxide chlordane

PBB, TRIS, Curene-442, and Dioxin. Analytical data from soil samples submitted for SAS analysis by the U.S. EPA CLP indicate contamination with tris and to a lesser extent curene-442. A summary of PBB, tris, curene-442, and dioxin data is presented in Table 13. Based upon the limited sampling, soil contamination by tris and curene-442 is along the northwest margin of the site near the loading docks and Chem-Dyne building.

Dioxin analysis by the SAS program of the U.S. EPA CLP were for the 2, 3, 7, 8-TCDD isomer only. Dioxin results were "none detected" at reported detected limits ranging from 0.1 to 1.0 ug/kg. Separate dioxin analysis of six onsite soil

Table 11  
RELATIVE PERSISTENCE OF SEVERAL VOLATILE ORGANIC  
COMPOUNDS IDENTIFIED IN SOIL SAMPLES FROM CHEM-DYNE

<u>Compound</u>	<u>Relative Persistence<sup>a</sup></u>
toluene	somewhat persistent
benzene	somewhat persistent
1,2-dichloroethane	somewhat persistent
ethyl benzene	somewhat persistent
chlorobenzene	persistent
1,1,2-trichloroethene	persistent
methylene chloride	persistent
carbon tetrachloride	highly persistent
chloroform	highly persistent
tetrachloroethane	highly persistent
1,1,2-trichloroethane	highly persistent

<sup>a</sup>Persistence evaluation taken from the National Oil and Hazardous Substances Contingency Plan (40 CFR Part 300, Table 5).

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Table 12  
SUMMARY OF THE OCCURRENCE OF PESTICIDE COMPOUNDS IN SOIL SAMPLES

<u>Pesticide</u>	<u>Sample Location</u>	<u>Maximum Concentration ug/kg</u>
Aldrin	SS (1,9,10); TP(7-2)	2,990 (TP-7-2) <sup>a</sup>
Dieldrin	OS (1,3,4); SS (6,7,8,9,10) TP (7-1, 7-2); GS(1)	24,600 (TP-7-2)
4,4'-DDT	OS(1,2); MW-25; TP (7-1,7-2)	7,900 (TP-7-2)
4,4'-DDE	OS(2); MW-25; SS (3,5,6); TP (7-2)	1,600 (SS-5)
4,4'-DDD	TP(11-1)	720 (TP-11-1)
Endrin	OS(3); SS (5,6,7,8,9,10) TP (7-1, 7-2, 11-1, 11-2, 12-1, 13-2, 13-3)	61,000 (SS-8)
Heptachlor	SS (8;9,10); TP (7-1, 7-2, 13-3); GS(1)	3,500 (TP-7-2)
-BHC	TP (7-1)	39 (TP-7-1)
β-BHC	SS (8,9); TP(7-1)	367 (TP-7-1)
γ-BHC (lindane)	TP (7-1, 7-2)	3,450 (TP-7-2)
Endosulfan sulfate	TP (2-5); SS (6)	10 (TP-2-5)
PCB-1260 <sup>b</sup>	OS(3,4); SS(5,7,8)	38,000 (OS-3)
Chlordane	OS(1); SS (7,8,9)	580,000 (SS-7)
Heptachlor Epoxide	GS(1)	135 (GS-1)

<sup>a</sup> Sample location associated with maximum concentration enclosed in parenthesis.

<sup>b</sup> PCB reported as PCB-1260.

Table 13  
SUMMARY OF PBB, TRIS, CURENE-442, AND DIOXIN ANALYSIS OF  
SOIL AT CHEM-DYNE UNDER SAS 735E

<u>Sample Location</u>	<u>Depth (Feet)</u>	<u>Compounds<sup>a,b</sup> Detected</u>	<u>Concentration (ug/kg)</u>
TP-1-1	0-2	ND	--
TP-1-3	5-6	ND	--
TP-3-1	0-1	ND	--
TP-5-1	0.5 - 1.5	ND	--
TP-10-1	0.5 - 1.5	ND	--
TP-10-3	3.5 - 4.5	ND	--
TP-11-2	1.5 - 2.5	Tris	360
TP-13-1	0-1	Tris	200,000
TP-13-3	3 - 3.5	Tris	2,000
GS-1	Surface	Tris Curene-442	2,000 260
GS-3	Surface	ND	--

<sup>a</sup>ND denotes PBB, tris, or Curene-442 not detected at reported detection limits of 100 ug/kg for PBB and Curene-442 and 200 ug/kg for tris.

<sup>b</sup>2,3,7,8-TCDD (dioxin) was analyzed for but not detected at reported detection limits of 0.1 to 1.0 ug/kg.

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samples from April detected no dioxin at a calculated detection limit of 0.05 ug/kg. Therefore, potential dioxin contamination of soil at the site was eliminated from consideration.

Tris is considered a carcinogen by the National Cancer Institute. Curene-442 is an OSHA carcinogen. Standards are not set for permissible concentrations or exposure limits of tris and/or curene-442 in air, water, or soil. Evaluation of the mobility and persistence of these two compounds was not made due to the indeterminable interactions possible in the site's complex chemical and physical soil environment.

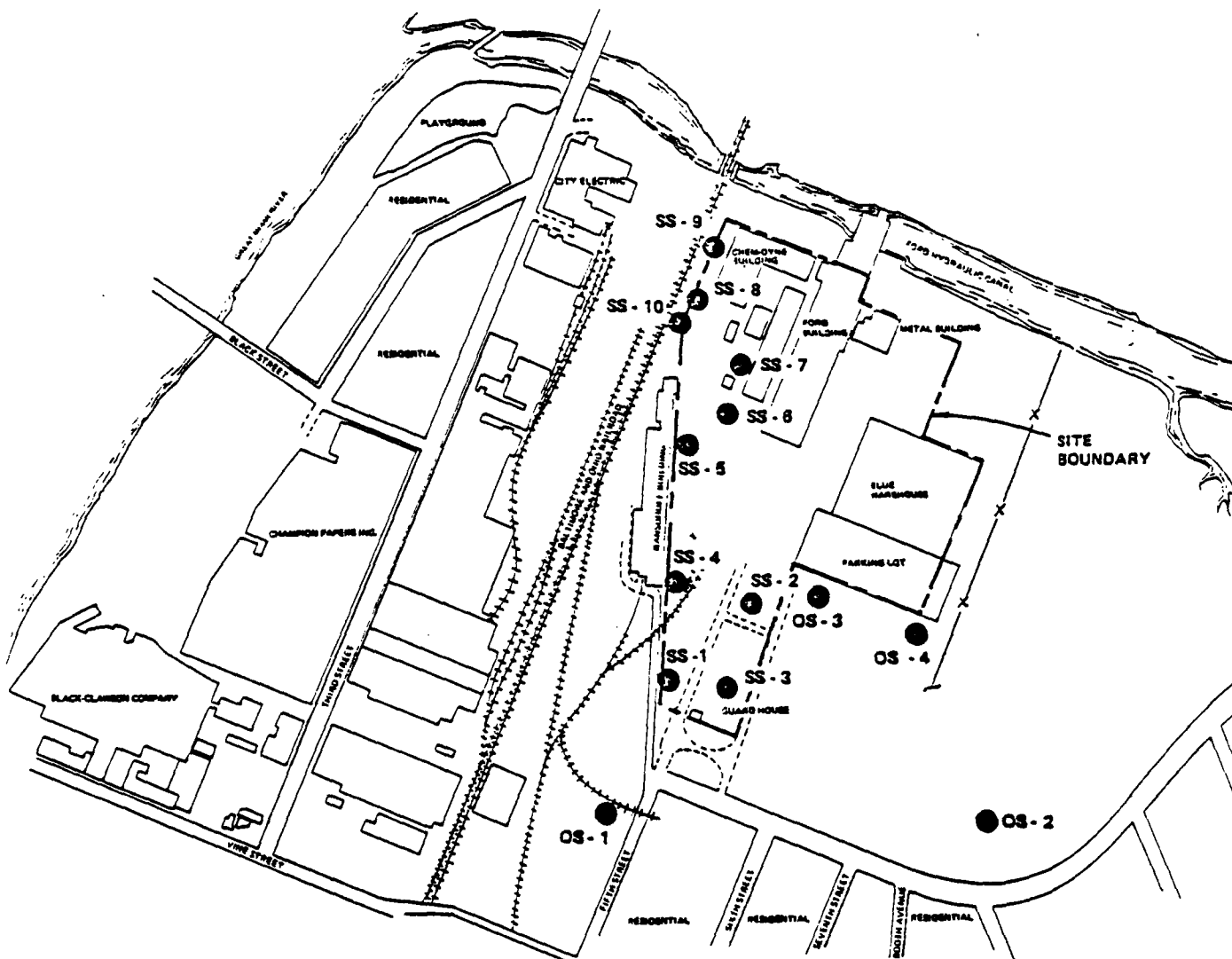
#### GENERAL CONCLUSIONS AND OBSERVATIONS

General conclusions and observations concerning soil at the Chem-Dyne site are as follows:

- o A stratigraphic horizon of gray silt and/or greenish sandy silty clay, important to understanding the hydrogeologic conditions at the site, is absent beneath the site and appears to be present west of the site as discontinuous zones or remnants.
- o Significantly high concentrations (concentrations an order of magnitude or more greater than reported for offsite soil unaffected by Chem-Dyne operations) of inorganic constituents were primarily associated with surface or near surface soil (approximately the upper 5 feet).
- o Significantly high concentrations of tin and mercury were reported from samples collected in soil test pits outside the eastern fenced perimeter of the site (TP-1 and TP-2).
- o Primary organic soil contaminants include priority pollutant pesticides, base/neutral compounds, and volatile organic compounds.
- o All areas sampled within the fenced perimeter of the site and one area outside (soil test pit TP-2) indicated soil contamination by organic compounds.
- o Soil contamination by organic compounds appears greatest, in both frequency and concentration, in

surface or near surface soil (approximately the upper 10 feet).

- o Mobilities of organic and inorganic contaminants are uncertain due to complex and unknown interactions among factors affecting mobility, such as organic and inorganic constituents present, concentrations of soil constituents, percent soil organic matter, percent clay, and microbial activity.
- o Pesticides and many of the volatile and base/neutral organic compounds present in soil at the site are highly persistent (NCP classification).
- o Several of the pesticides, volatile organics, and base/neutral compounds present in surface soil at the site are considered carcinogenic.



#### LEGEND

● SAMPLING LOCATION

OS - 1 DENOTES OFFSITE SOIL SAMPLE 1

SS - 1 DENOTES SURFACE SOIL SAMPLE 1

NOTE: More detailed descriptions of sampling locations are presented in the TM for subtask 3 - 1

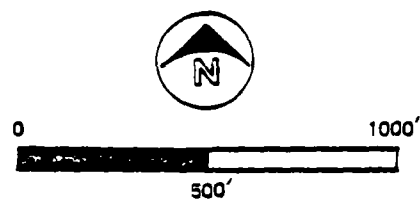
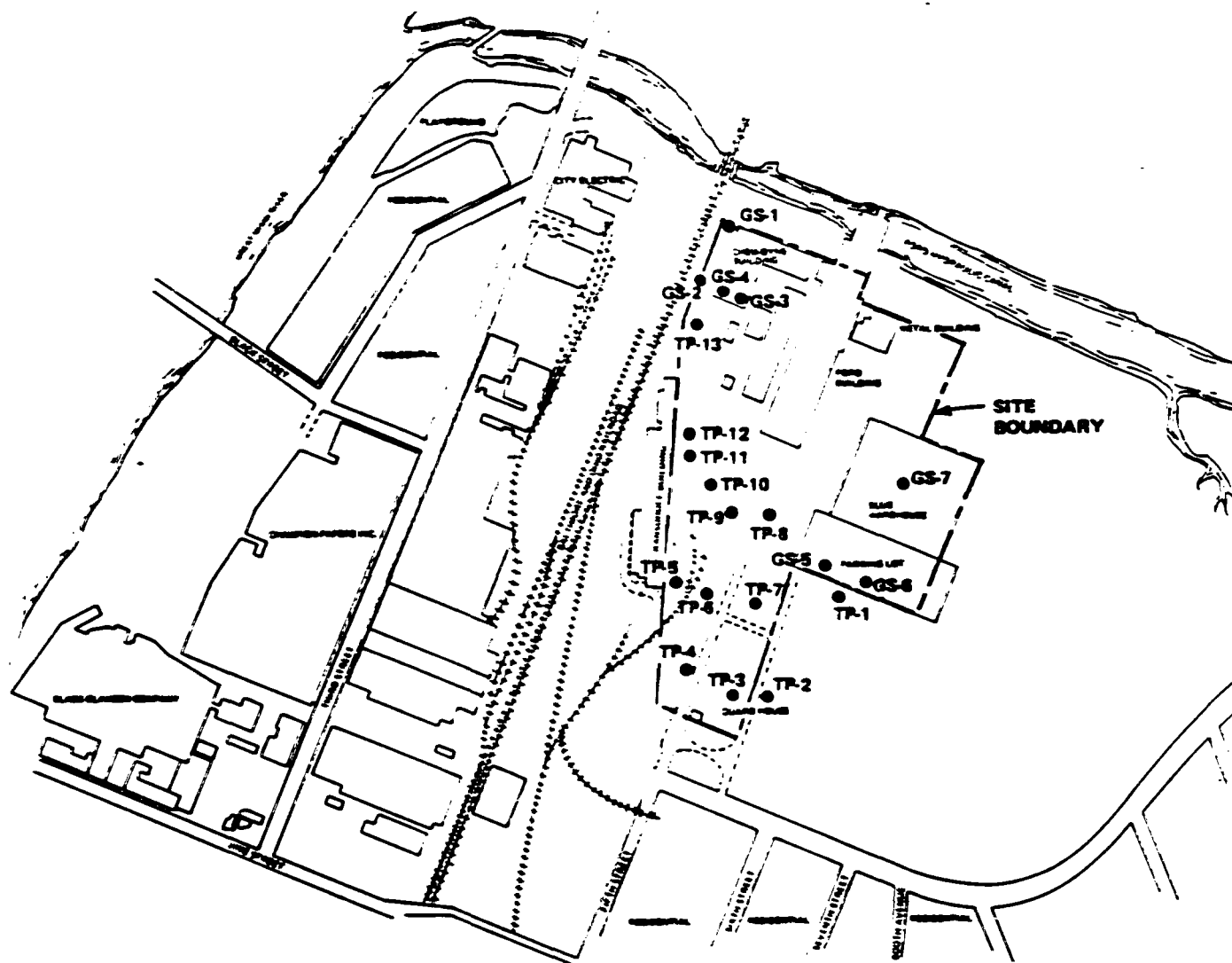


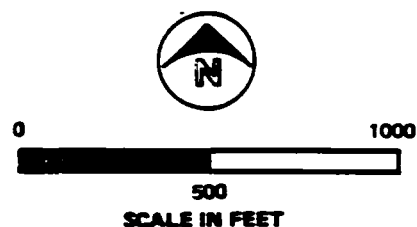
FIGURE 4  
APPROXIMATE SURFACE  
SOIL SAMPLE LOCATIONS  
APRIL 11 - 12, 1983  
CHEM - DYNE RI



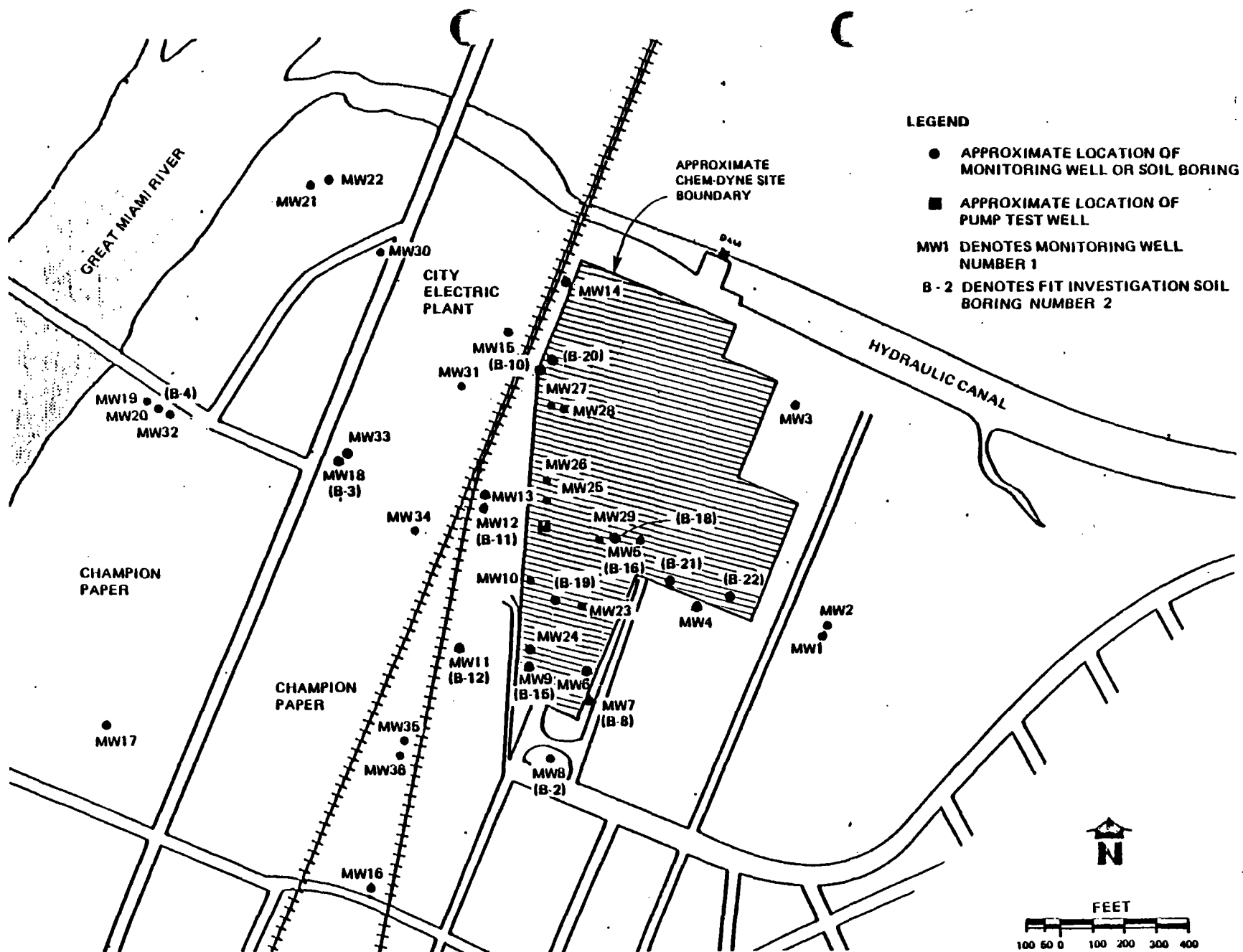
#### LEGEND

- TEST PIT OR "GRAB" SAMPLE LOCATION
- TP-1 TEST PIT NO. 1
- GS-1 "GRAB" SAMPLE NO. 1

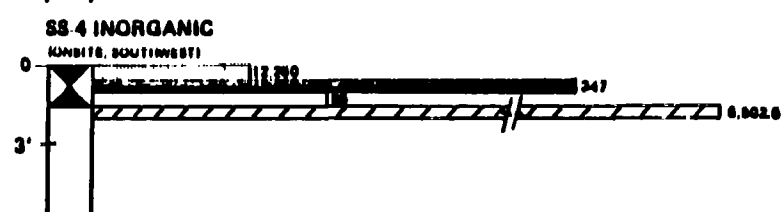
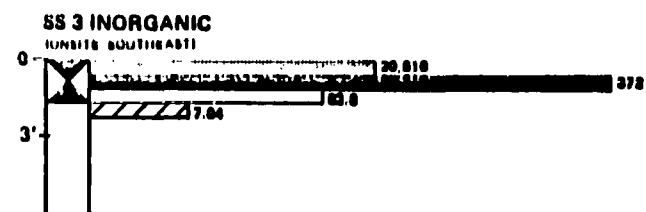
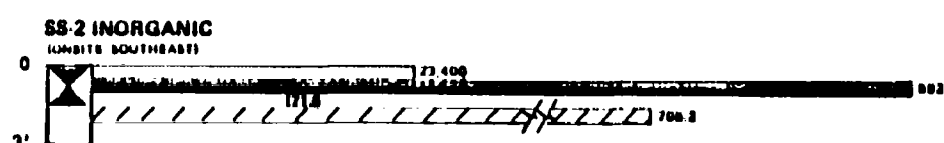
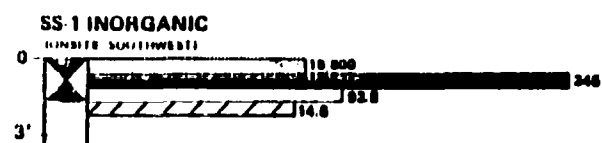
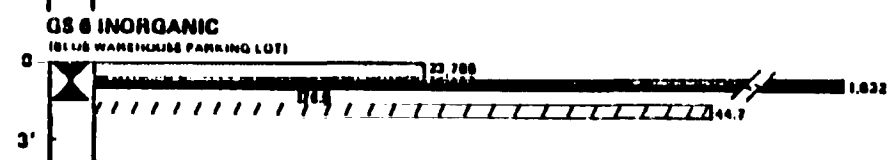
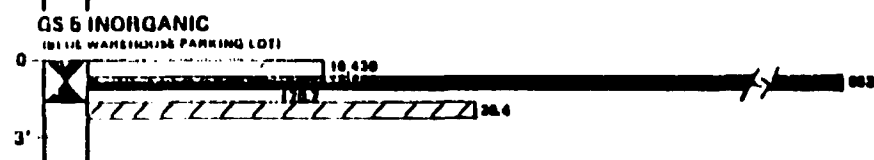
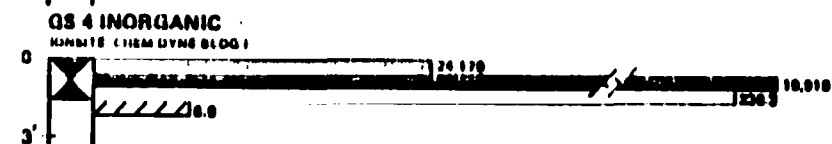
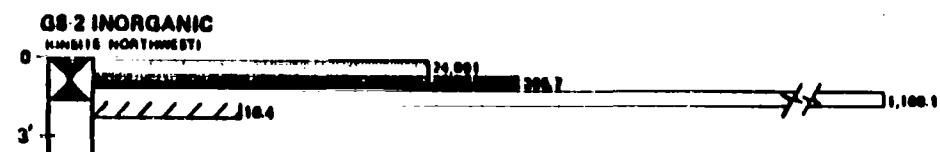
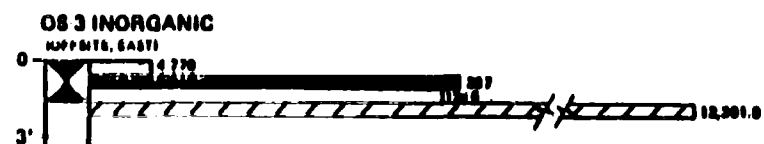
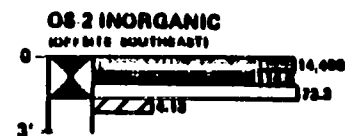
NOTE: More detailed descriptions of sampling locations are presented in the TM for subtask 3 - 4



**FIGURE 5**  
**FINAL SOIL INVESTIGATION**  
**TEST PIT AND "GRAB" SAMPLE LOCATIONS**  
**CHEM-DYNE SITE**



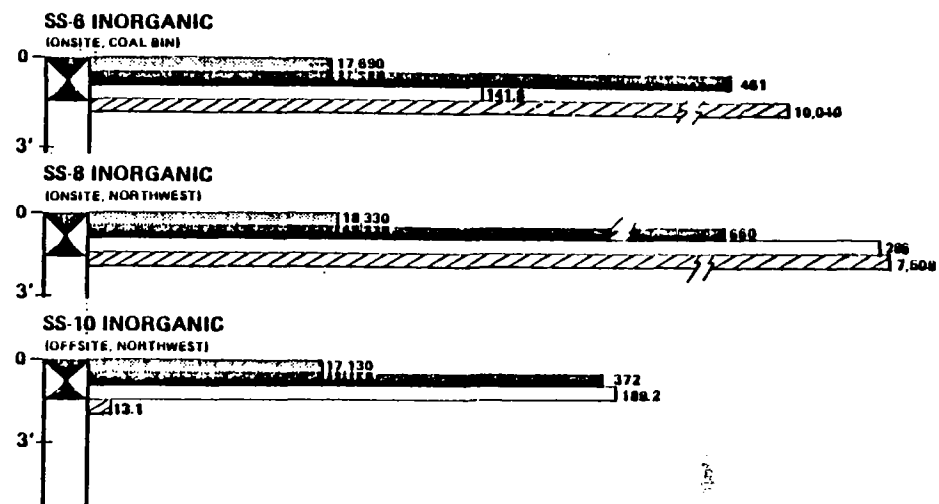
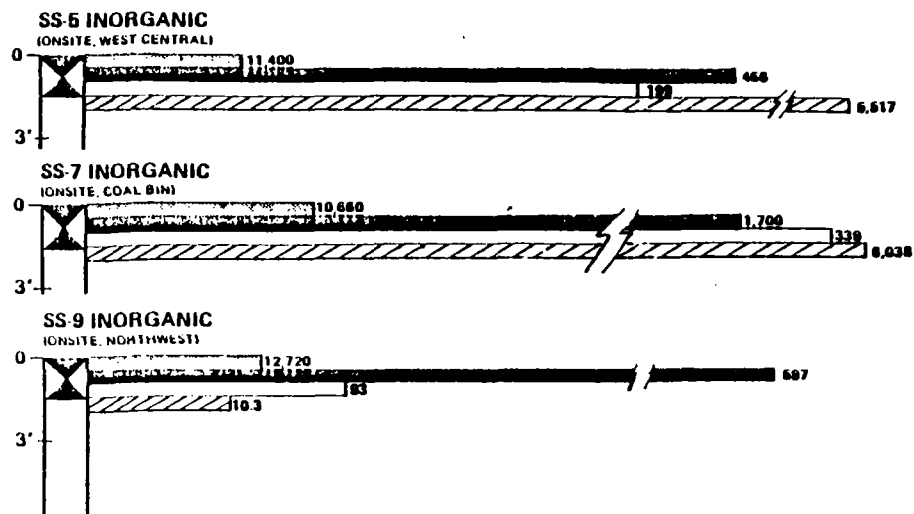
**FIGURE 6**  
**LOCATIONS OF MONITORING WELLS**  
**AND SOIL BORINGS**  
**CHEM - DYNE RI**



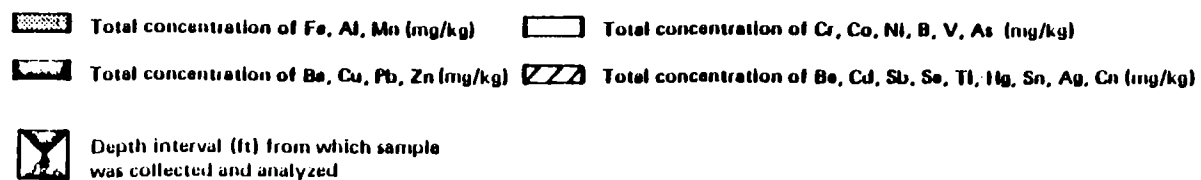
# **LEGEND**

- Total concentration of Fe, Al, Mn (mg/kg)
- Total concentration of Cr, Co, Ni, B, V, As (mg/kg)
- Total concentration of Se, Cu, Pb, Zn (mg/kg)
- Total concentration of Se, Cd, Sb, Se, Ti, Hg, Sn, Ag, Cn (mg/kg)
- Depth interval (ft) from which sample was collected and analyzed

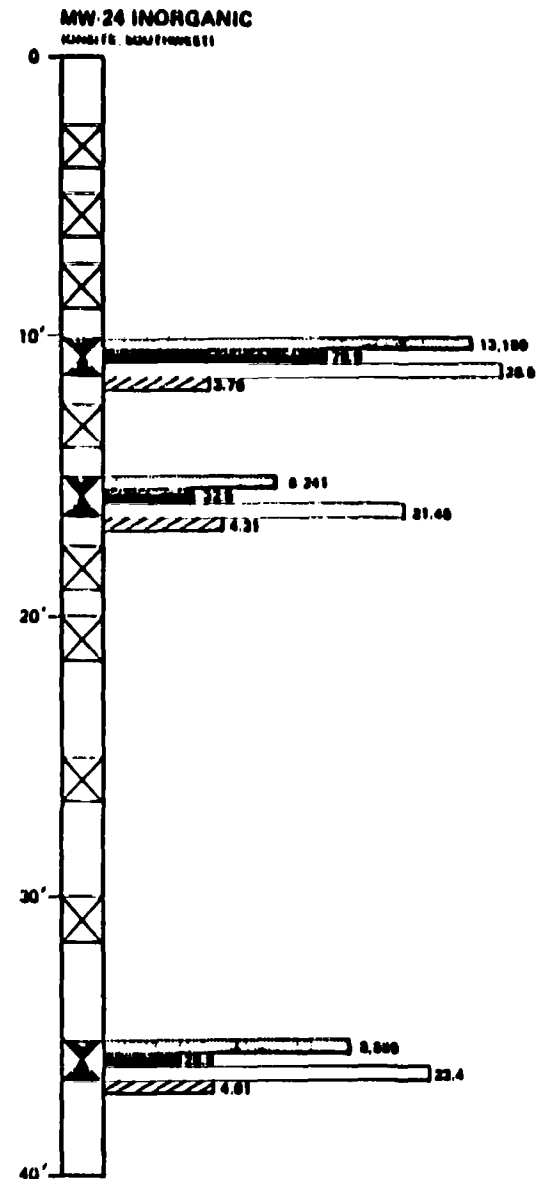
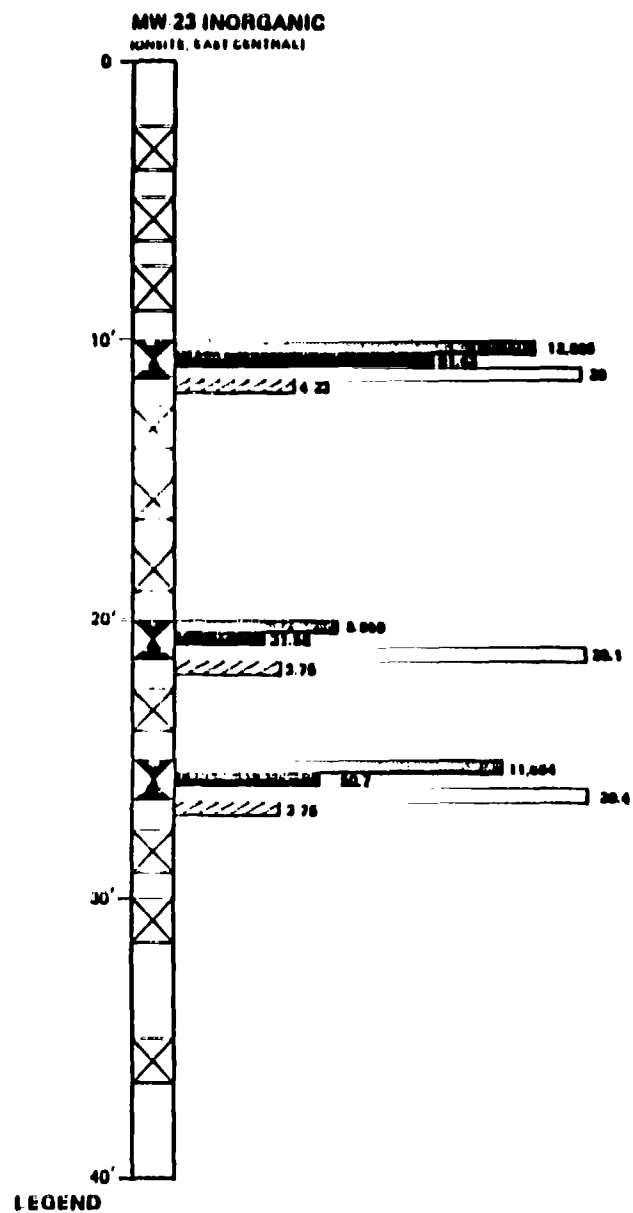
**FIGURE 7 a**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SURFACE SOIL SAMPLES**  
**CIEM - DYNE RI**



# LEGEND



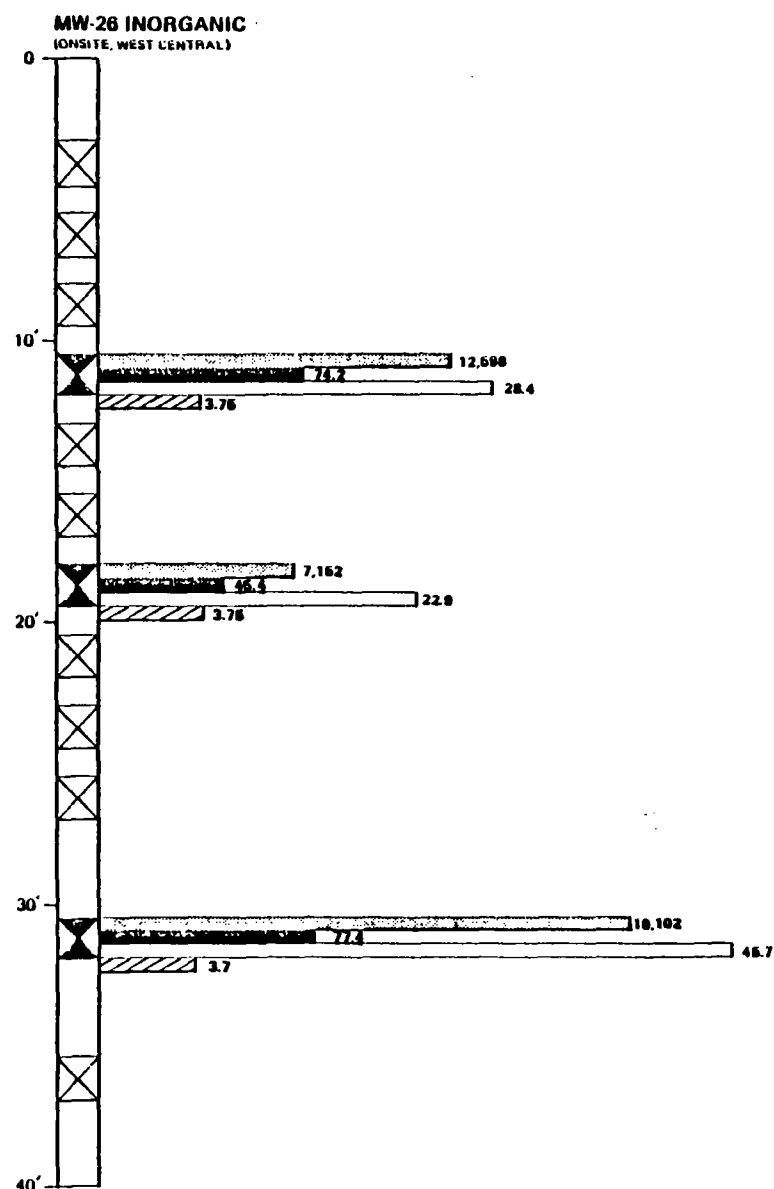
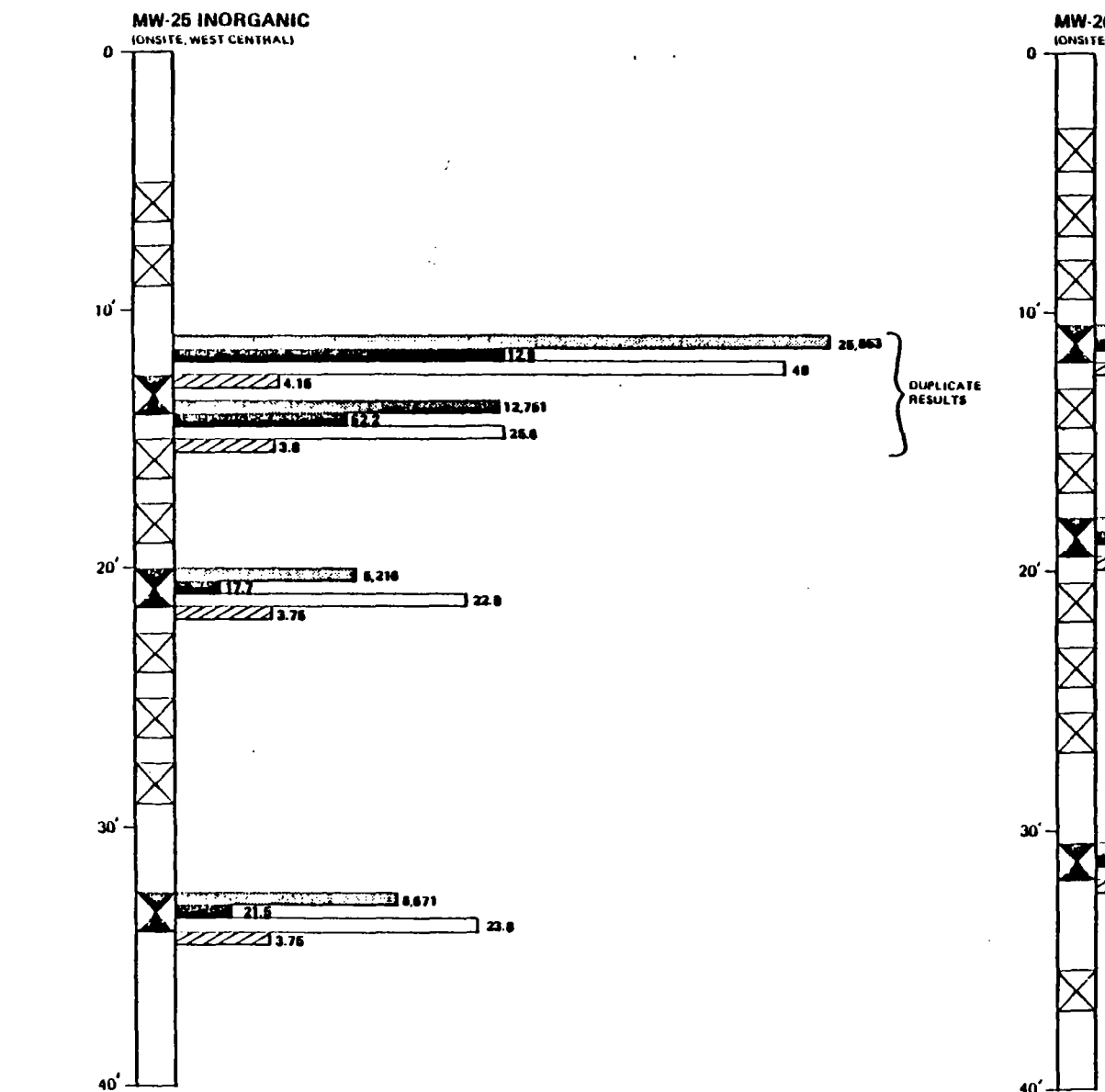
**FIGURE 7b**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE RI



**LEGEND**

	Total concentration of Fe, Al, Mn (mg/kg)		Total concentration of Cr, Co, Ni, B, V, As (mg/kg)
	Total concentration of Ba, Cu, Pb, Zn (mg/kg)		Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cn (mg/kg)
	Depth Interval (ft) from which sample was collected and analyzed		Depth Interval (ft) from which sample was collected but not analyzed

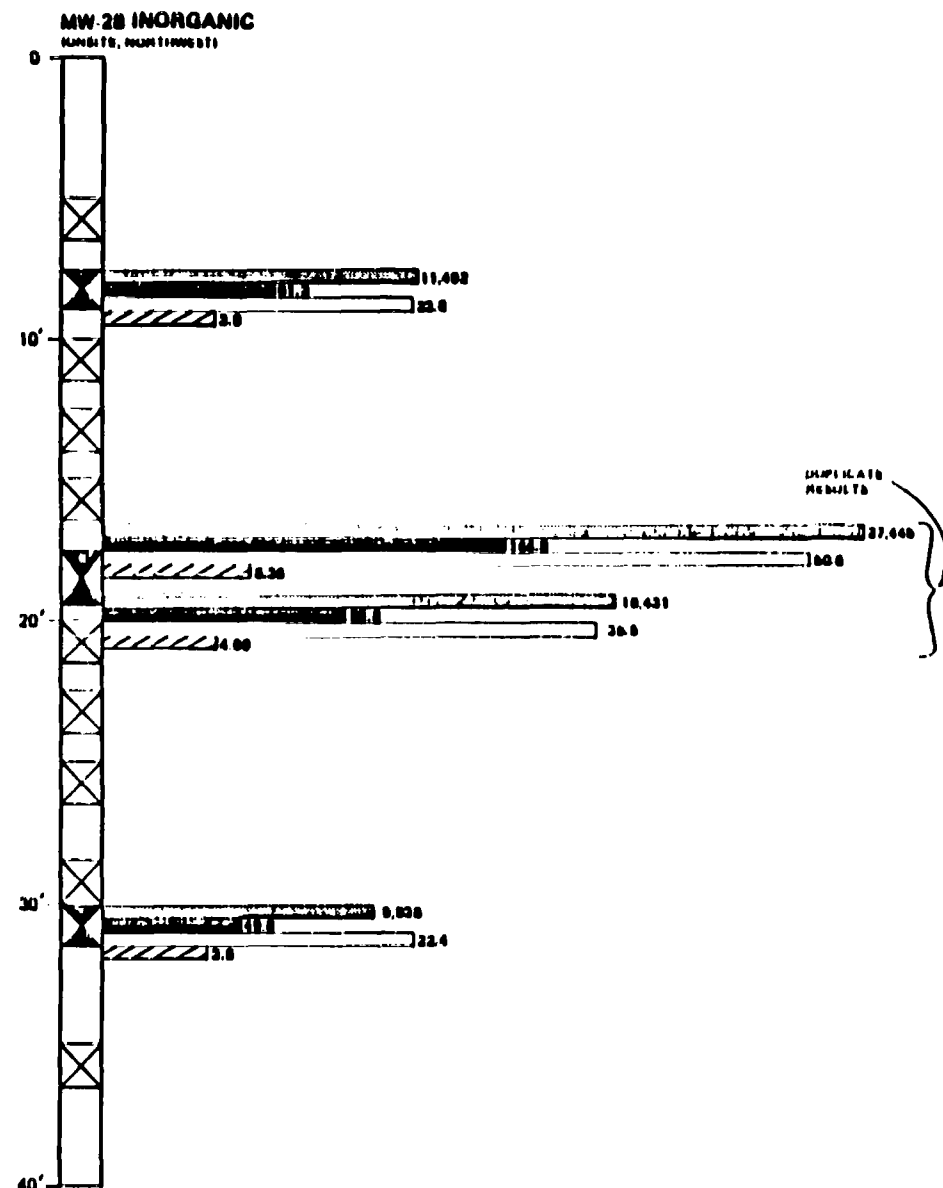
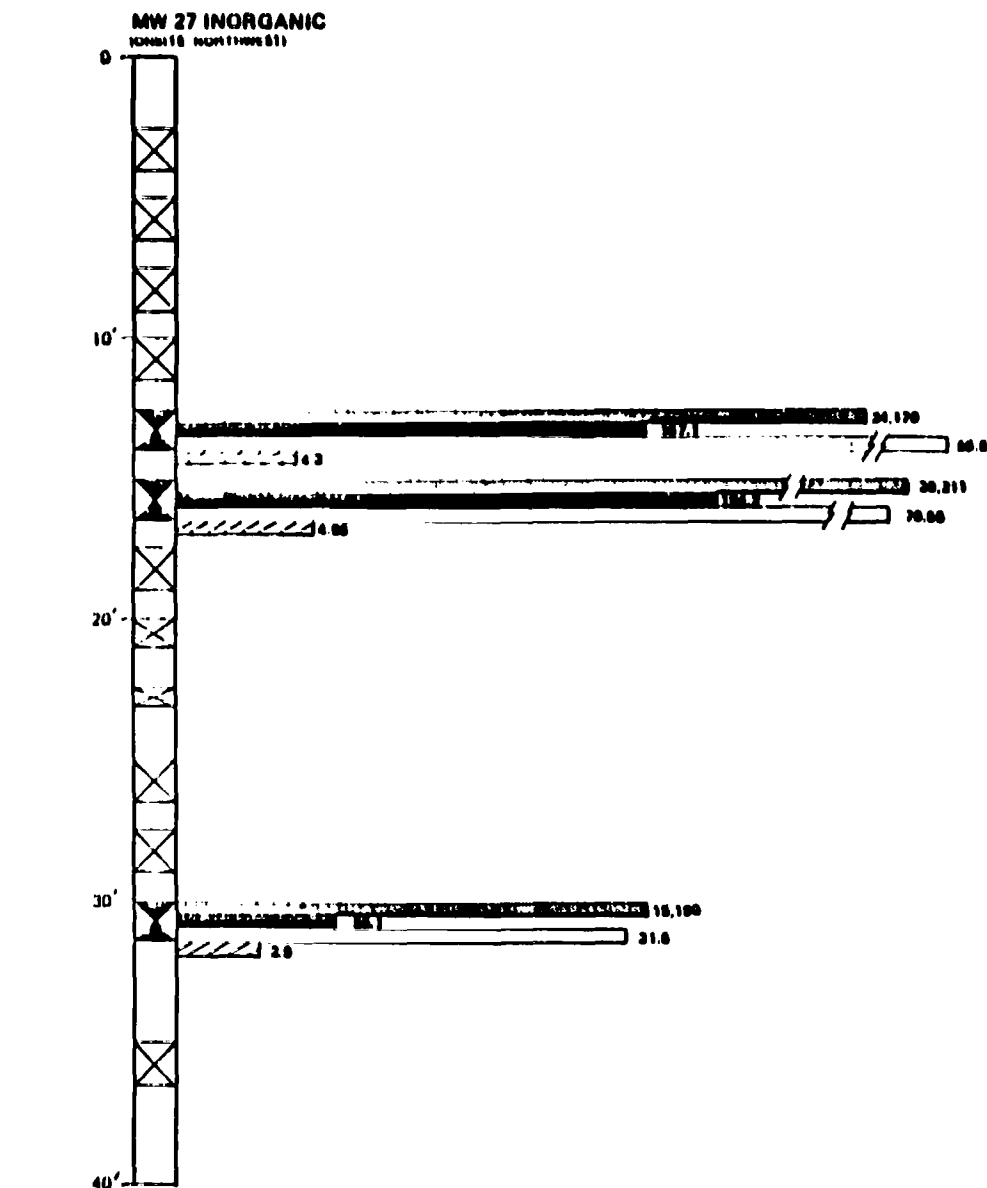
**FIGURE 8 a**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CHEM-DYNE HI



**LEGEND**

- |  |  |  |  |
|--|--|--|--|
|  | Total concentration of Fe, Al, Mn (mg/kg)                        |  | Total concentration of Cr, Co, Ni, B, V, As (mg/kg)                  |
|  | Total concentration of Be, Cu, Pb, Zn (mg/kg)                    |  | Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cn (mg/kg)    |
|  | Depth interval (ft) from which sample was collected and analyzed |  | Depth interval (ft) from which sample was collected but not analyzed |

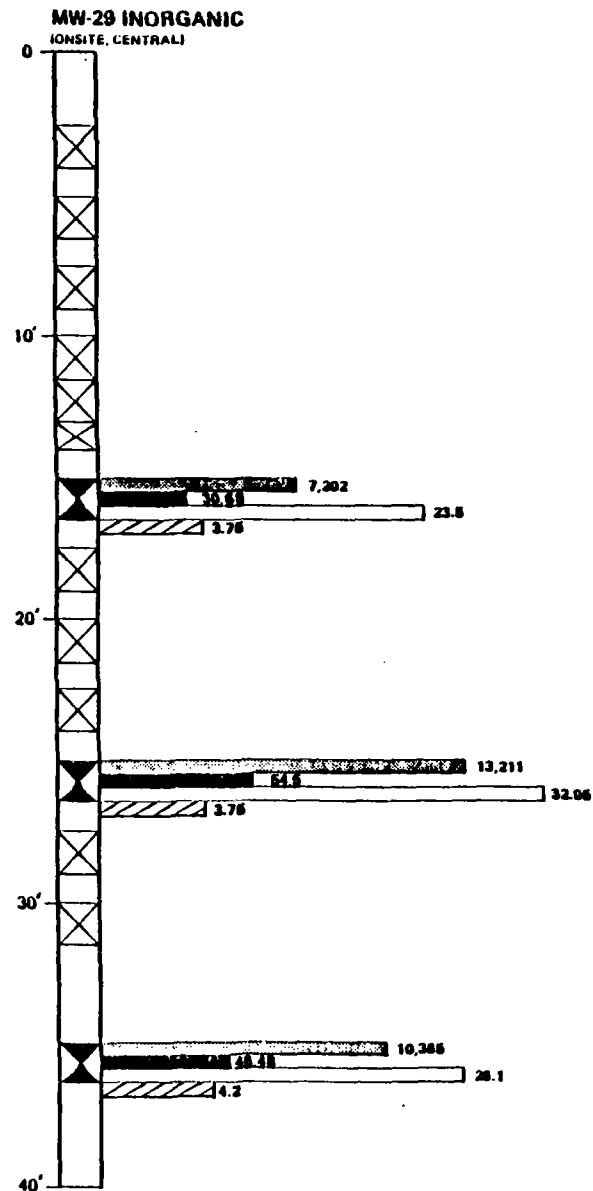
**FIGURE 8 b**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE RI



**LEGEND**

- |  |  |
|--|--|
| Total concentration of Fe, Al, Mn (mg/kg)                        | Total concentration of Cr, Co, Ni, B, V, As (mg/kg)                  |
| Total concentration of Ba, Cu, Pb, Zn (mg/kg)                    | Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cn (mg/kg)    |
| Depth Interval (ft) from which sample was collected and analyzed | Depth Interval (ft) from which sample was collected but not analyzed |

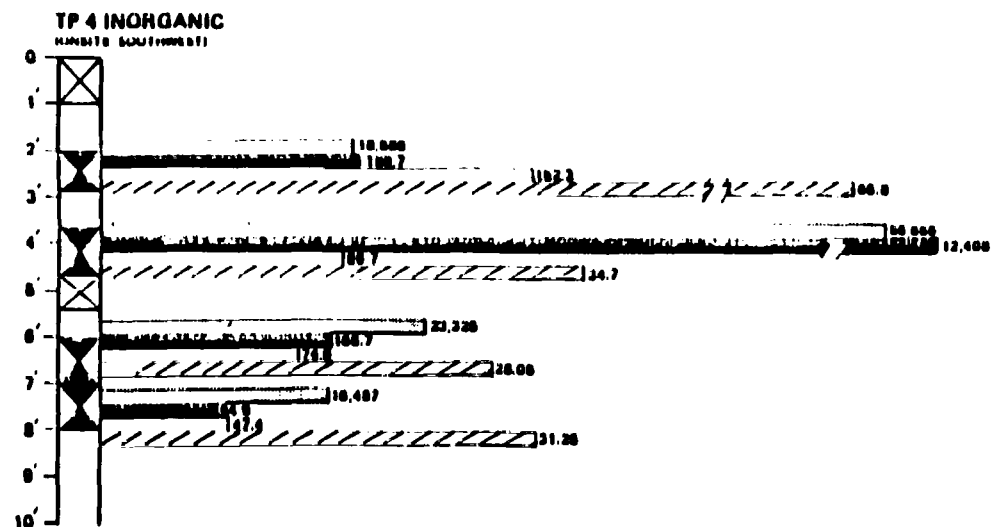
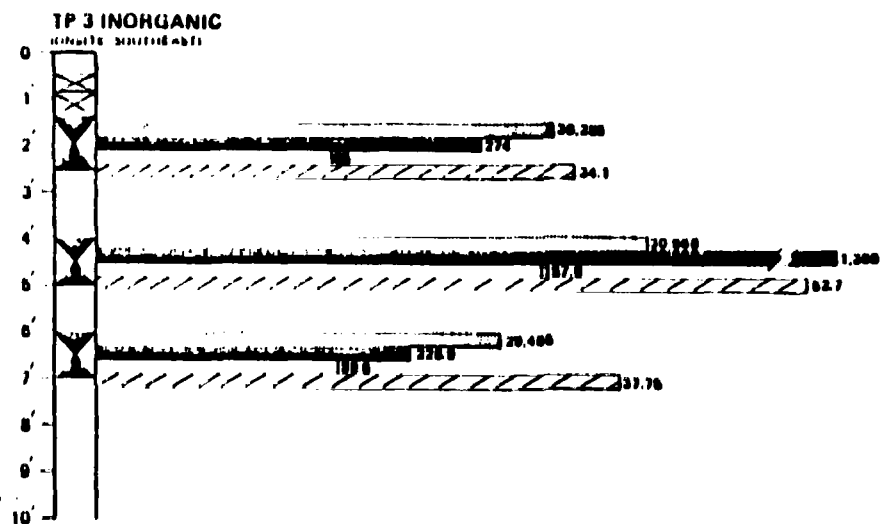
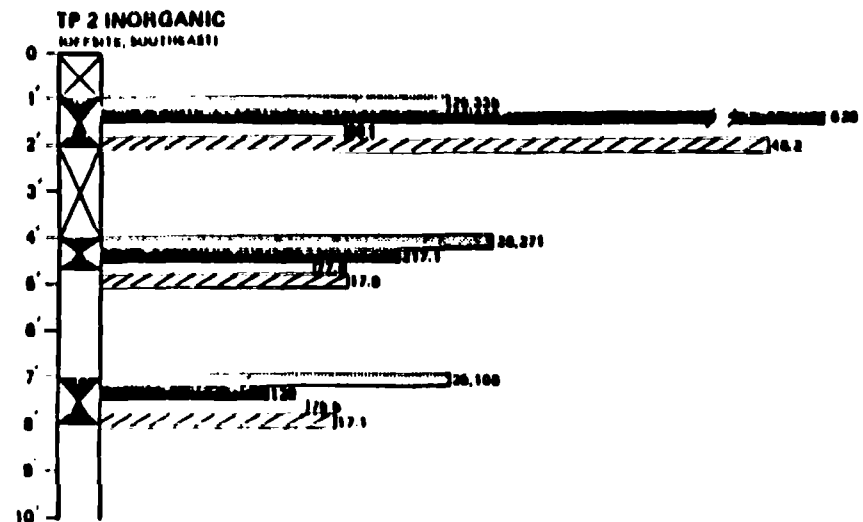
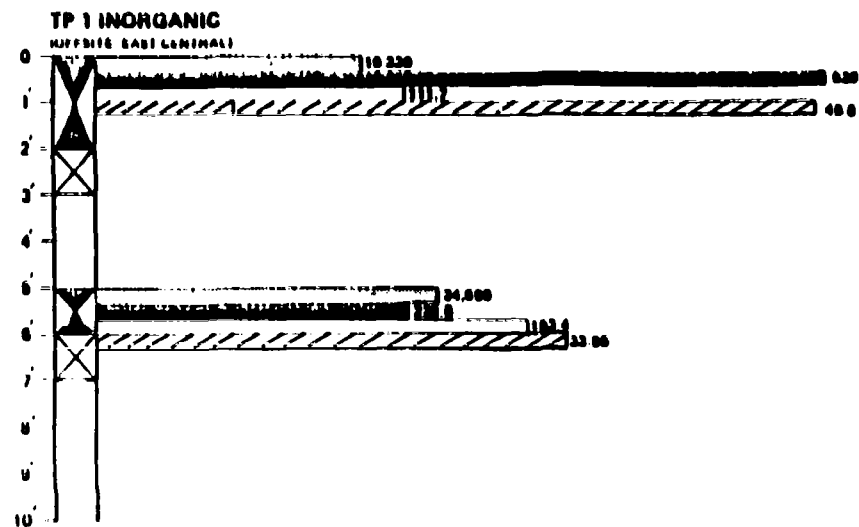
**FIGURE 8c**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE HI



**LEGEND**

- |  |  |
|--|--|
| Total concentration of Fe, Al, Mn (mg/kg)                        | Total concentration of Cr, Co, Ni, B, V, As (mg/kg)                  |
| Total concentration of Be, Cu, Pb, Zn (mg/kg)                    | Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cu (mg/kg)    |
| Depth interval (ft) from which sample was collected and analyzed | Depth interval (ft) from which sample was collected but not analyzed |

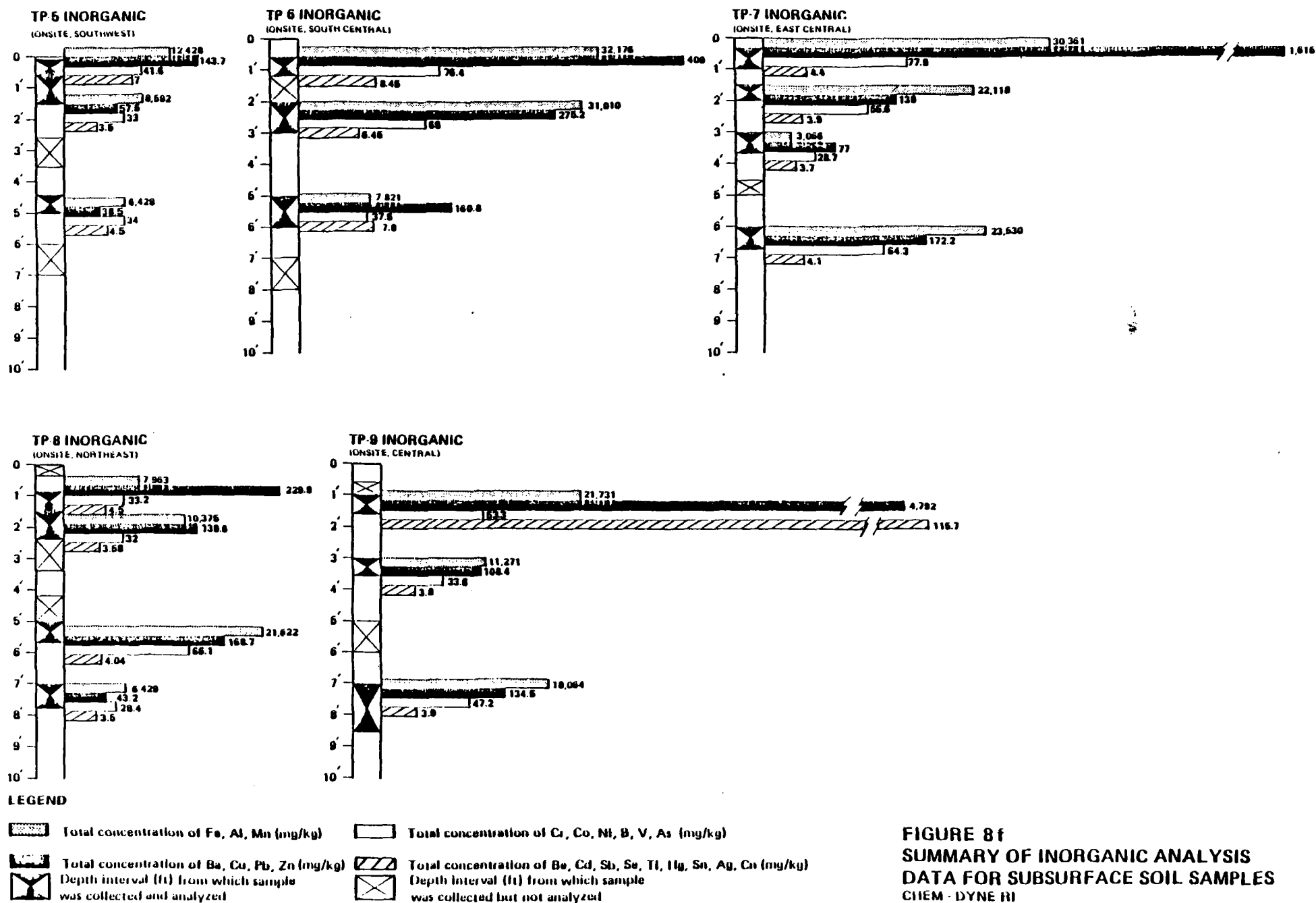
**FIGURE 8d**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE RI



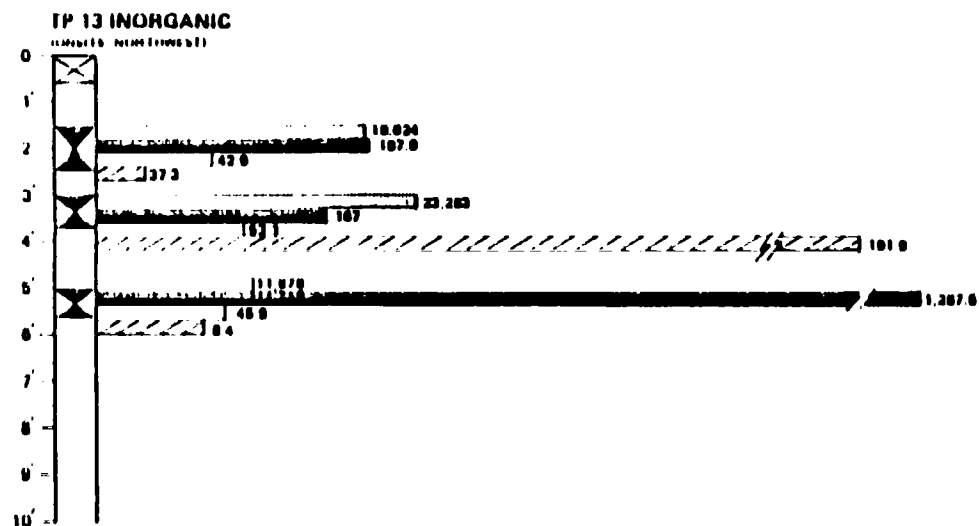
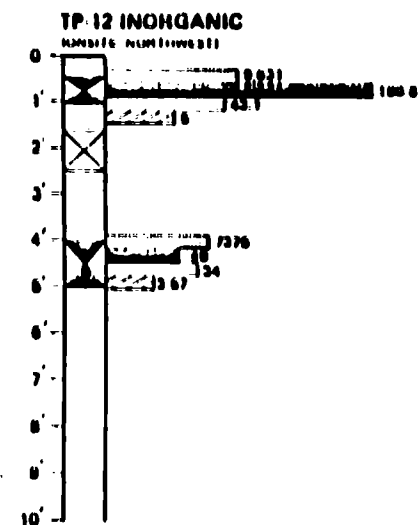
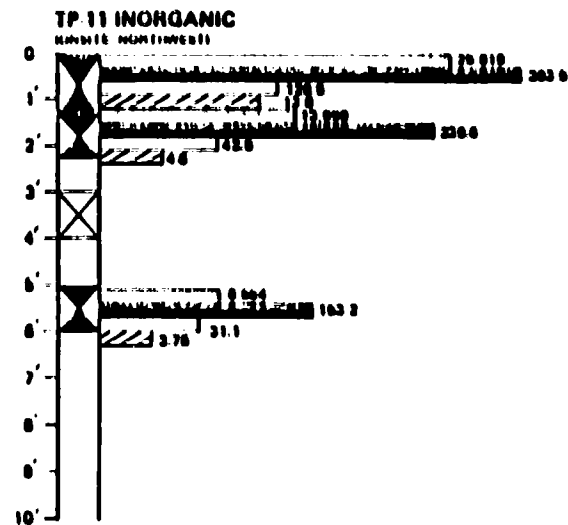
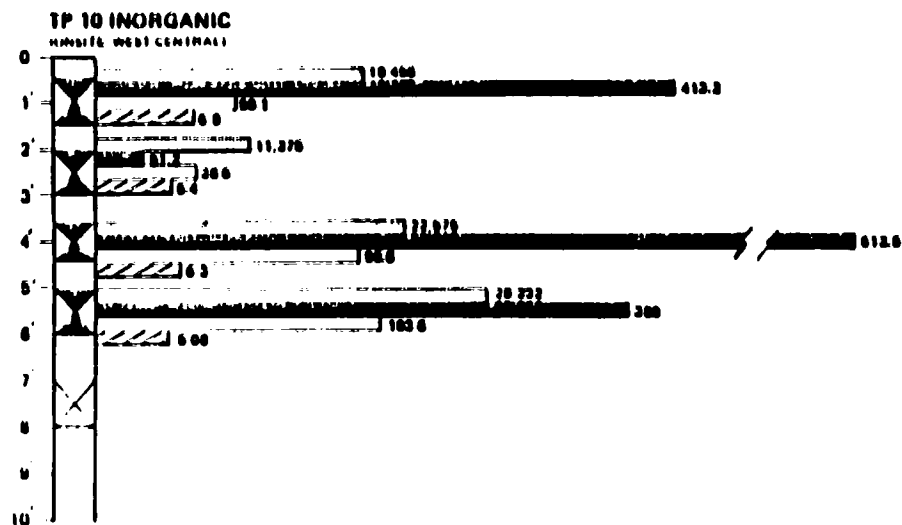
# **LEGEND**

	Total concentration of Fe, Al, Mn (mg/kg)		Total concentration of Cr, Co, Ni, B, V, As (mg/kg)
	Total concentration of Be, Cu, Pb, Zn (mg/kg)		Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cn (mg/kg)
	Depth interval (ft) from which sample was collected and analyzed		Depth interval (ft) from which sample was collected but not analyzed

**FIGURE 8e**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CHEM-DYNE HI



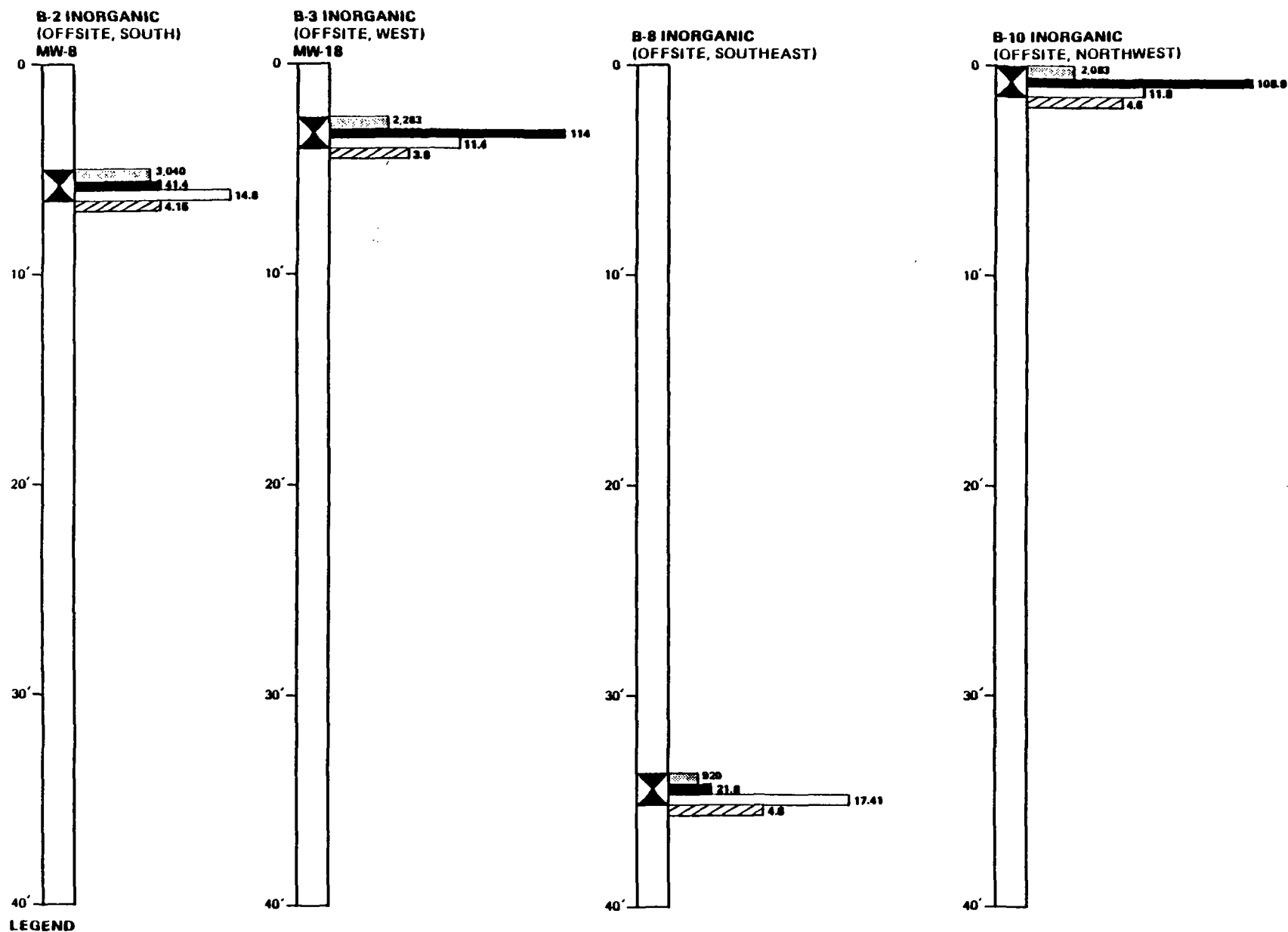
**FIGURE 8f**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE RI



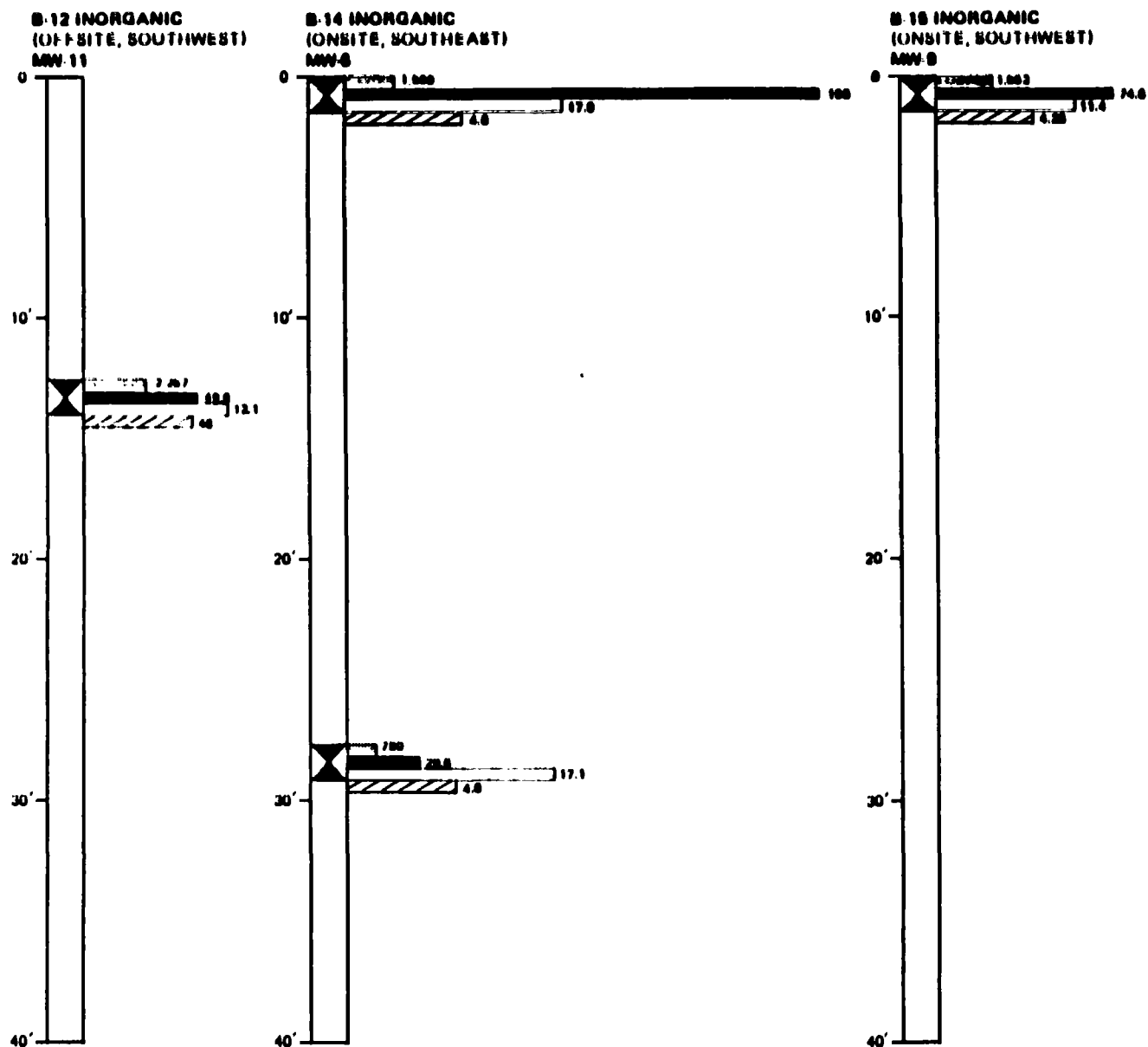
# LEGEND

	Total concentration of Fe, Al, Mn (mg/kg)		Total concentration of Cr, Co, Ni, B, V, As (mg/kg)
	Total concentration of Ba, Cu, Pb, Zn (mg/kg)		Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cn (mg/kg)
	Depth interval (ft) from which sample was collected and analyzed		Depth interval (ft) from which sample was collected but not analyzed

**FIGURE 8 g**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE HI



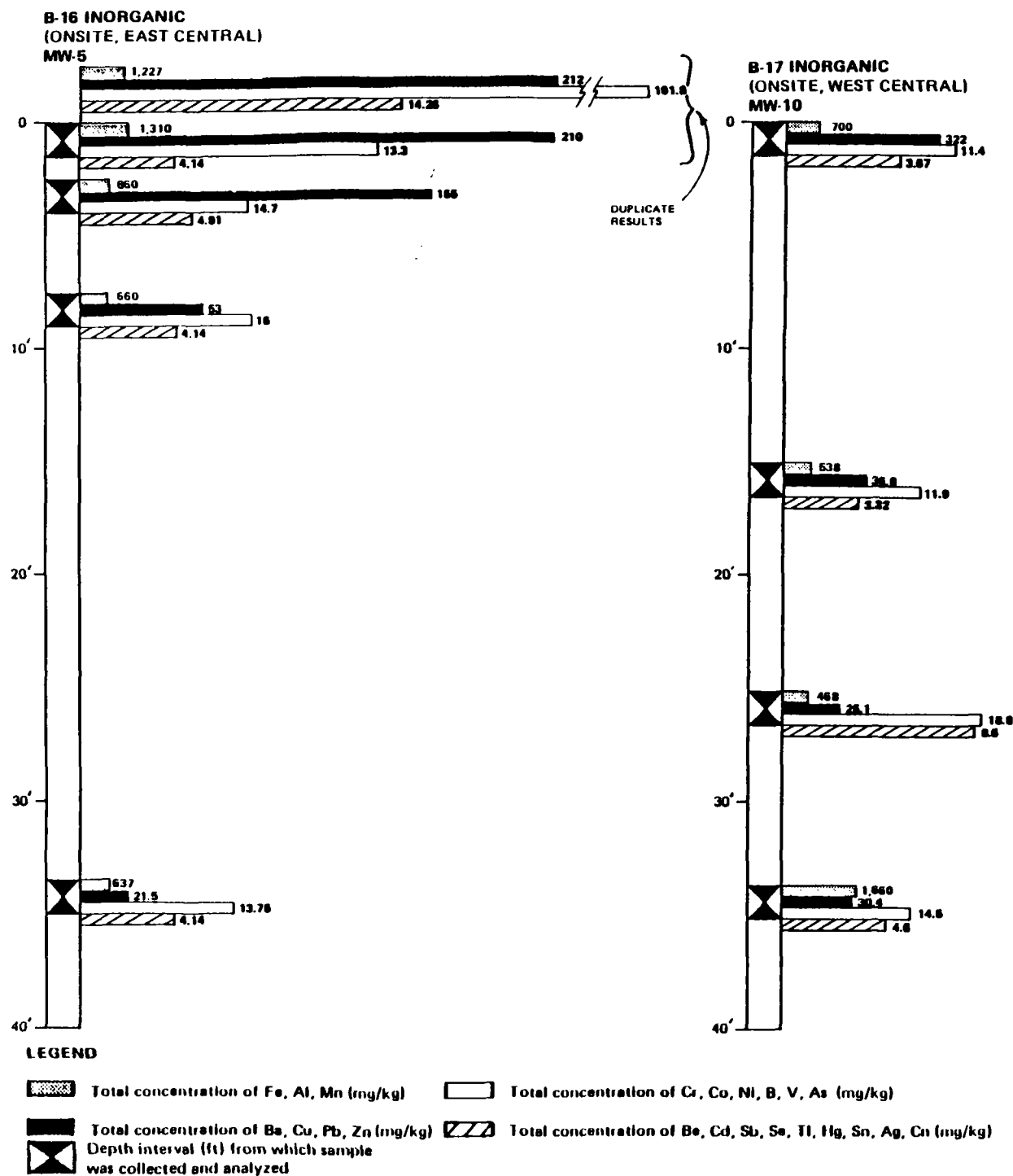
**FIGURE 9a**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FROM SOIL BORING SAMPLES**  
**COLLECTED DURING FIT INVESTIGATION**  
**CHEM - DYNE RI**



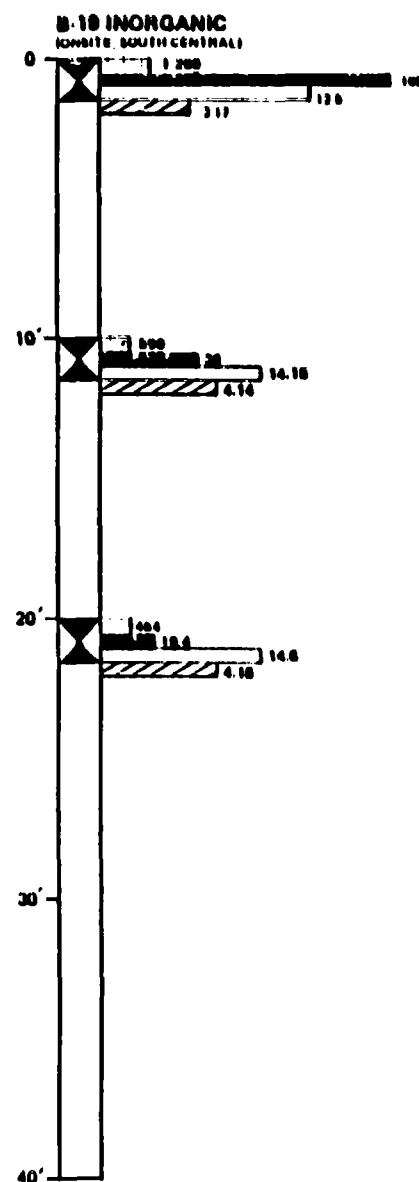
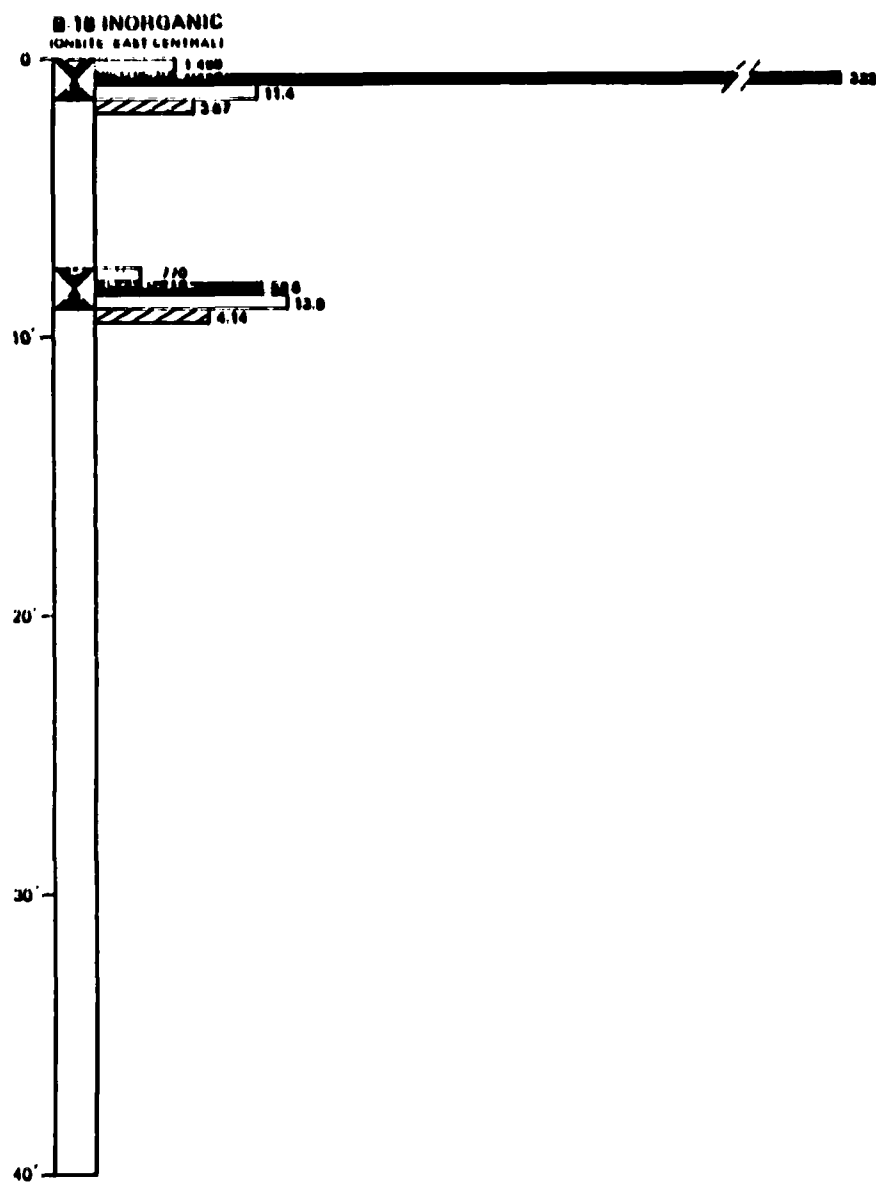
# **LEGEND**

- Total concentration of Fe, Al, Mn (mg/kg)
- Total concentration of Cr, Co, Ni, B, V, As (mg/kg)
- Total concentration of Be, Cu, Pb, Zn (mg/kg)
- Total concentration of Be, Cd, Sb, Se, Ti, Hg, Sn, Ag, Cn (mg/kg)
- Depth interval (ft) from which sample was collected and analyzed

**FIGURE 9b**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FROM SOIL BORING SAMPLES**  
**COLLECTED DURING FIT INVESTIGATION**  
 CHEM - DYNE RI



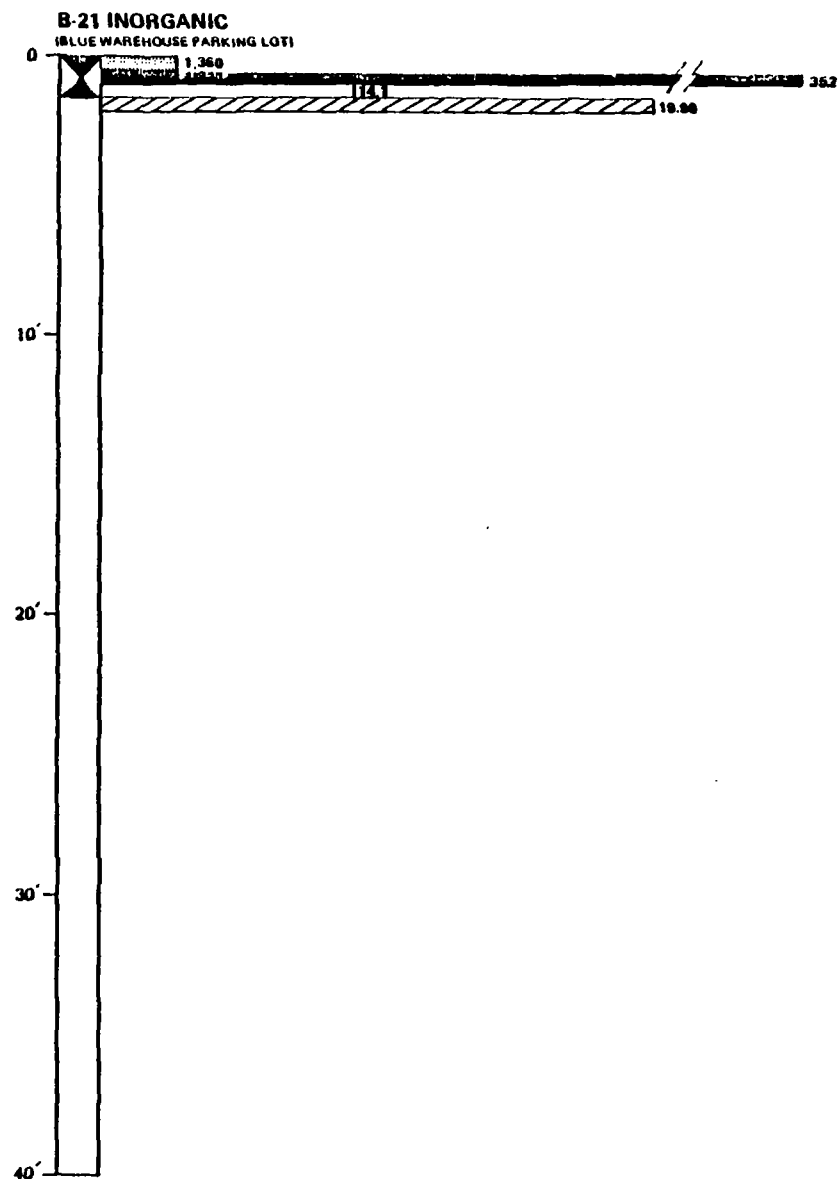
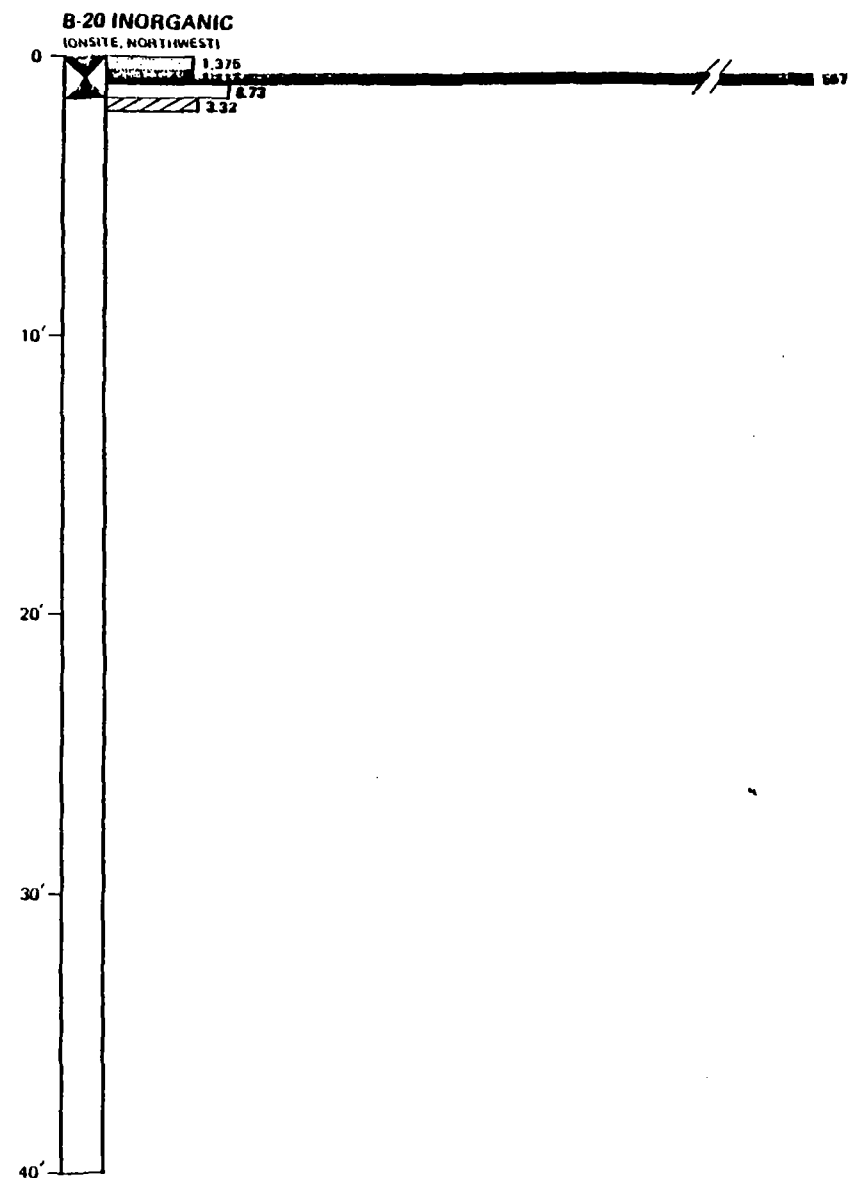
**FIGURE 9c**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FROM SOIL BORING SAMPLES**  
**COLLECTED DURING FIT INVESTIGATION**  
 CHEM - DYNE RI



# **LEGEND**

- |  |   |
|--|---|
| Total concentration of Fe, Al, Mn (mg/kg)                        | Total concentration of Cr, Co, Ni, B, V, As (mg/kg)               |
| Total concentration of Ba, Cu, Pb, Zn (mg/kg)                    | Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cn (mg/kg) |
| Depth interval (ft) from which sample was collected and analyzed |   |

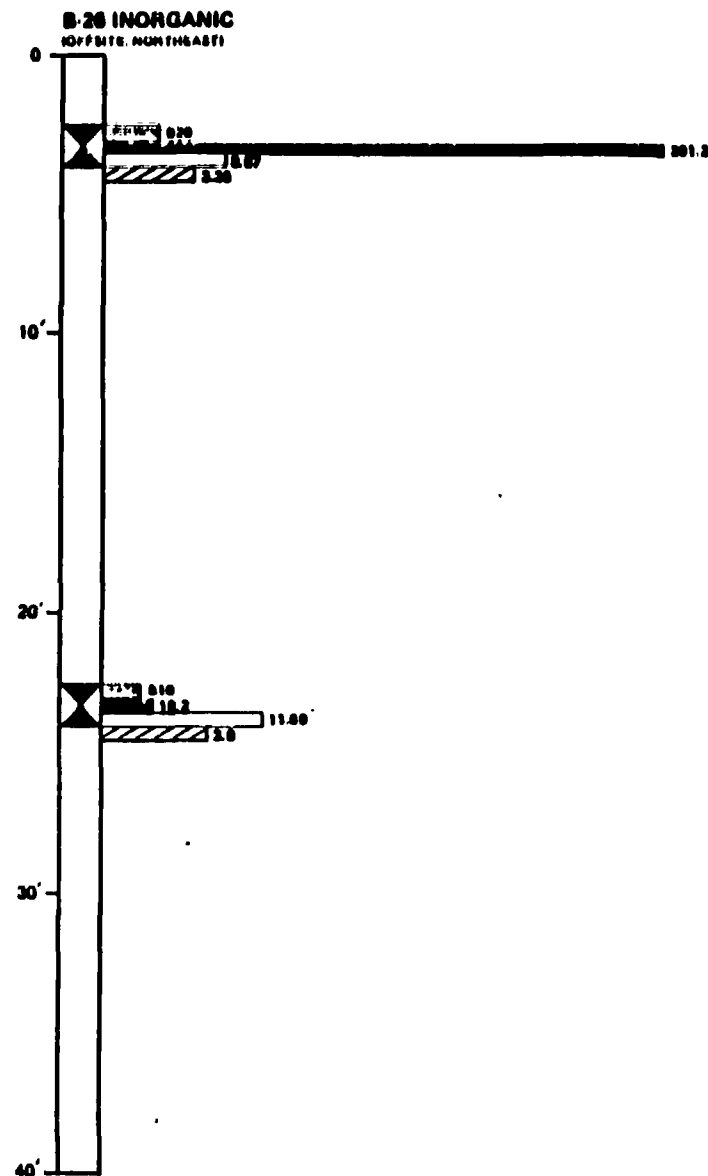
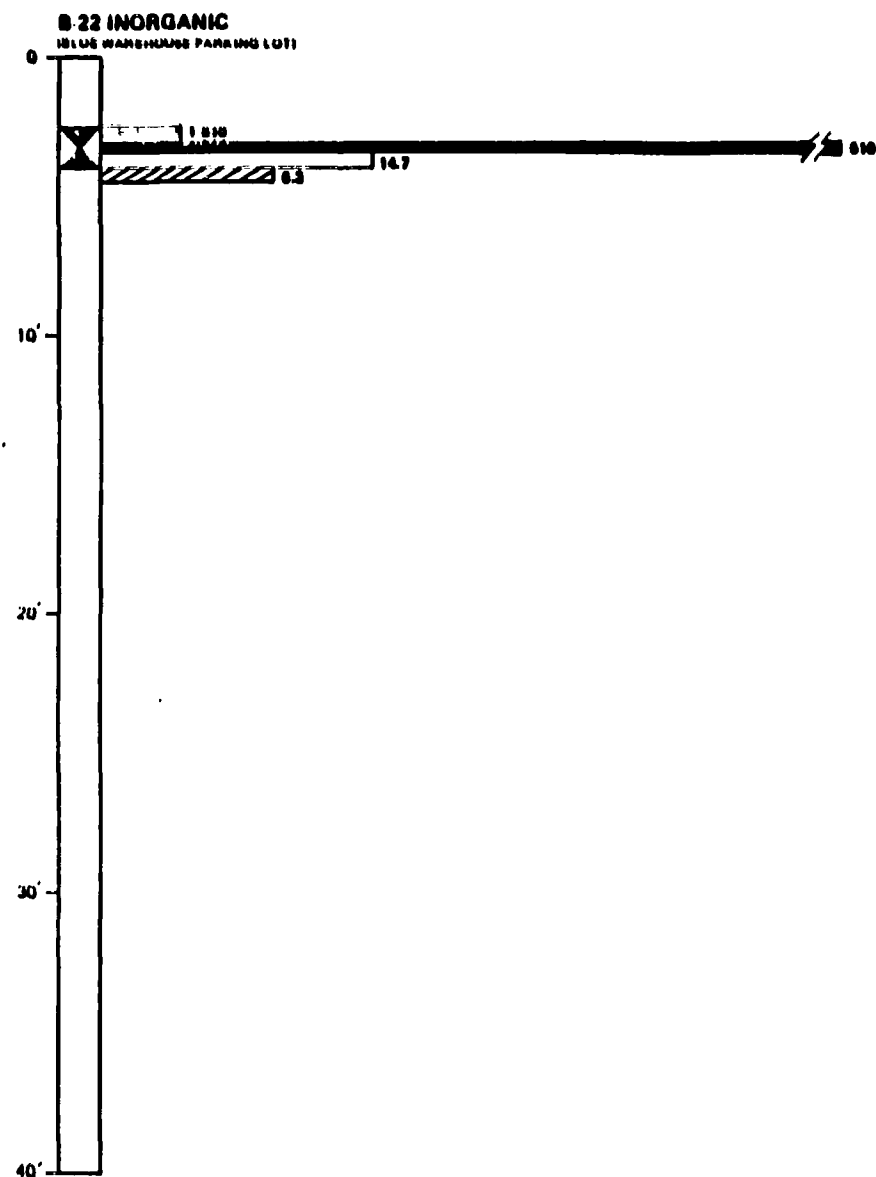
**FIGURE 9d**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FROM SOIL BORING SAMPLES**  
**COLLECTED DURING FIT INVESTIGATION**  
**CHEM-DYNE RI**



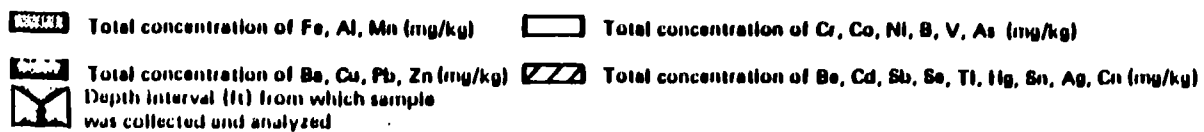
**LEGEND**

- |  |  |  |   |
|--|--|--|---|
|  | Total concentration of Fe, Al, Mn (mg/kg)                        |  | Total concentration of Cr, Co, Ni, B, V, As (mg/kg)               |
|  | Total concentration of Be, Cu, Pb, Zn (mg/kg)                    |  | Total concentration of Be, Cd, Sb, Se, Tl, Hg, Sn, Ag, Cn (mg/kg) |
|  | Depth interval (ft) from which sample was collected and analyzed |  |   |

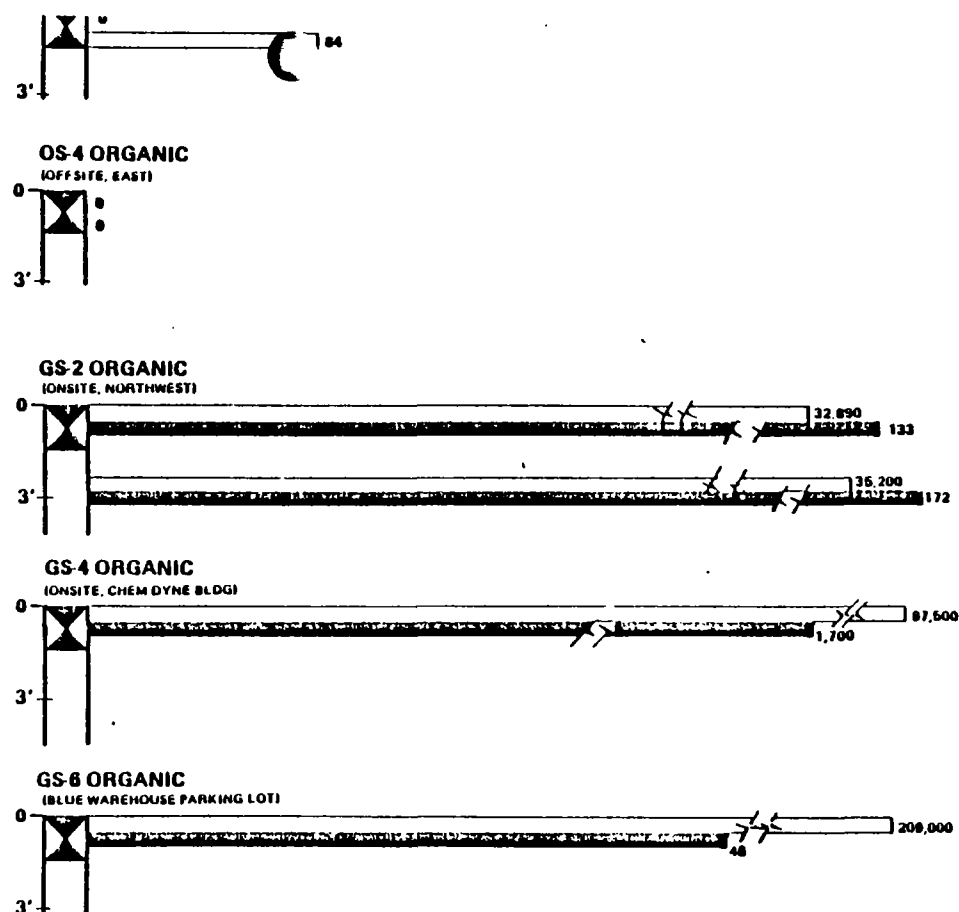
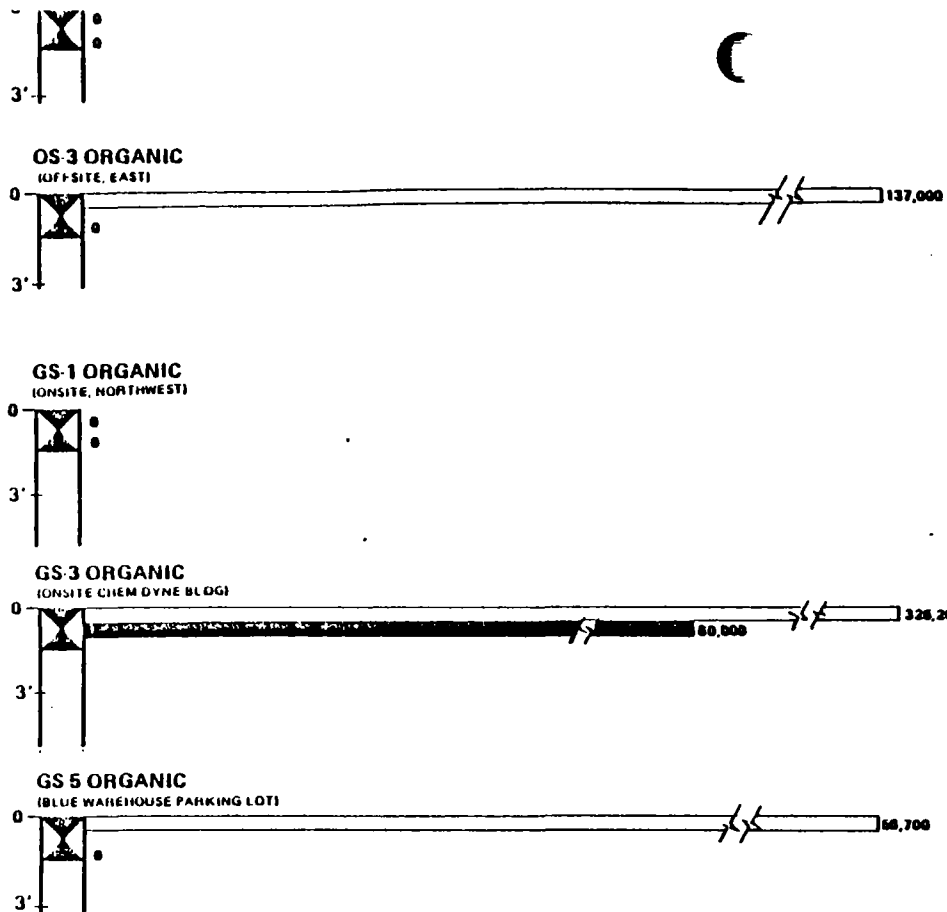
**FIGURE 9e**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FROM SOIL BORING SAMPLES**  
**COLLECTED DURING FIT INVESTIGATION**  
CIEM - DYNE RI






**LEGEND**



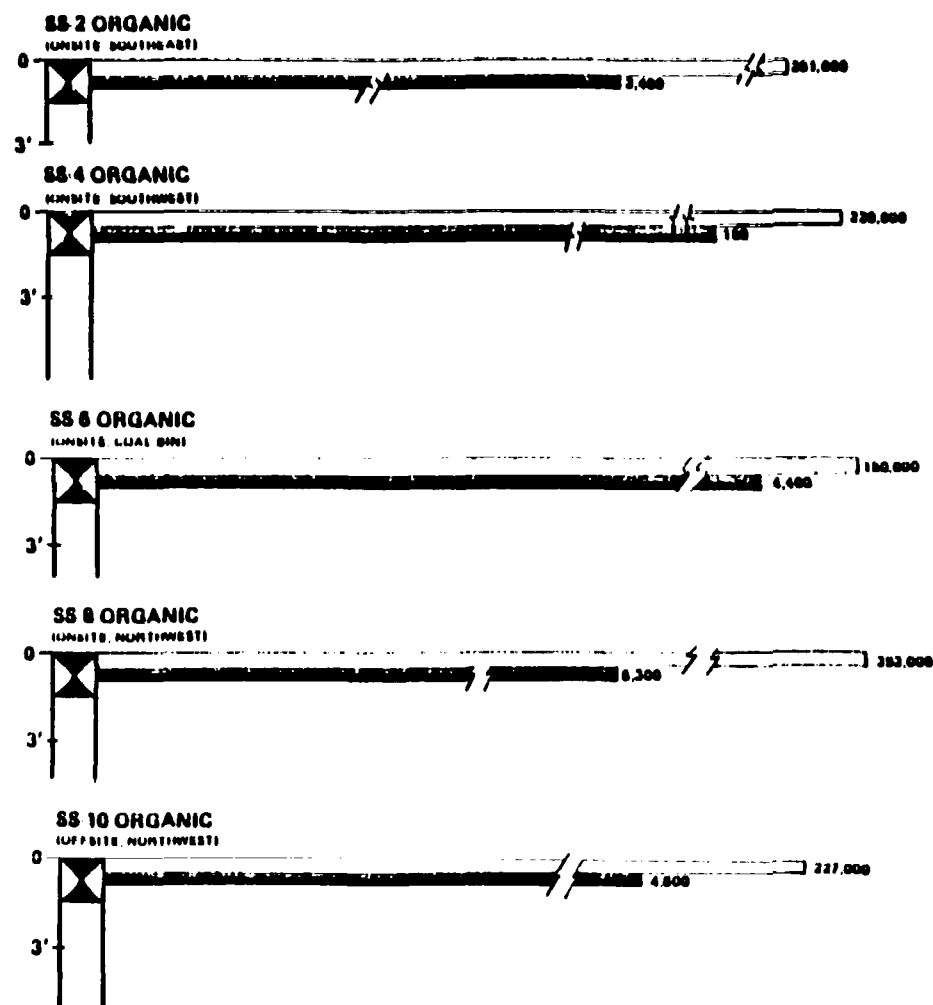
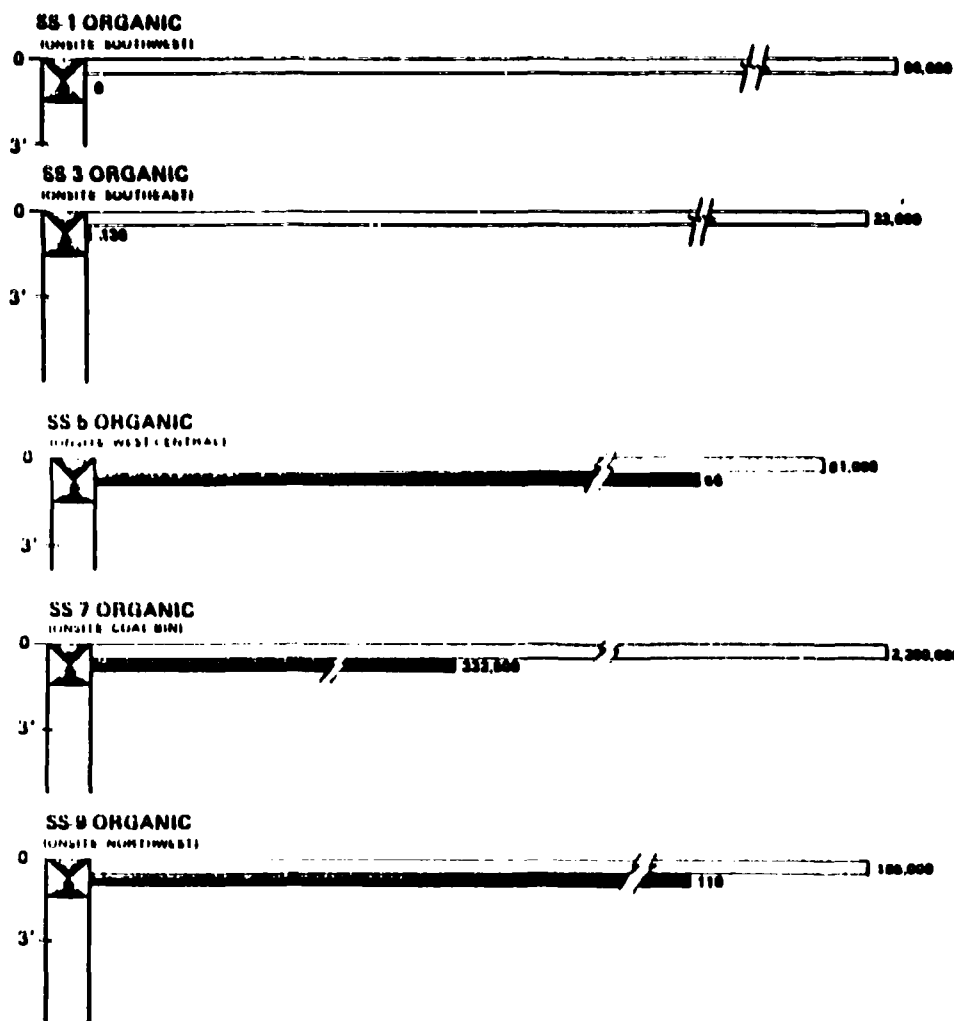
**FIGURE 9f**  
**SUMMARY OF INORGANIC ANALYSIS**  
**DATA FROM SOIL BORING SAMPLES**  
**COLLECTED DURING FIT INVESTIGATION**  
CIEM - DYNE RI






# LEGEND

-  Total concentration of Base/Neutral organic compounds ( $\mu\text{g}/\text{kg}$ )
-  Total concentration of Volatile organic compounds ( $\mu\text{g}/\text{kg}$ )
-  Depth interval (ft) from which sample was collected and analyzed

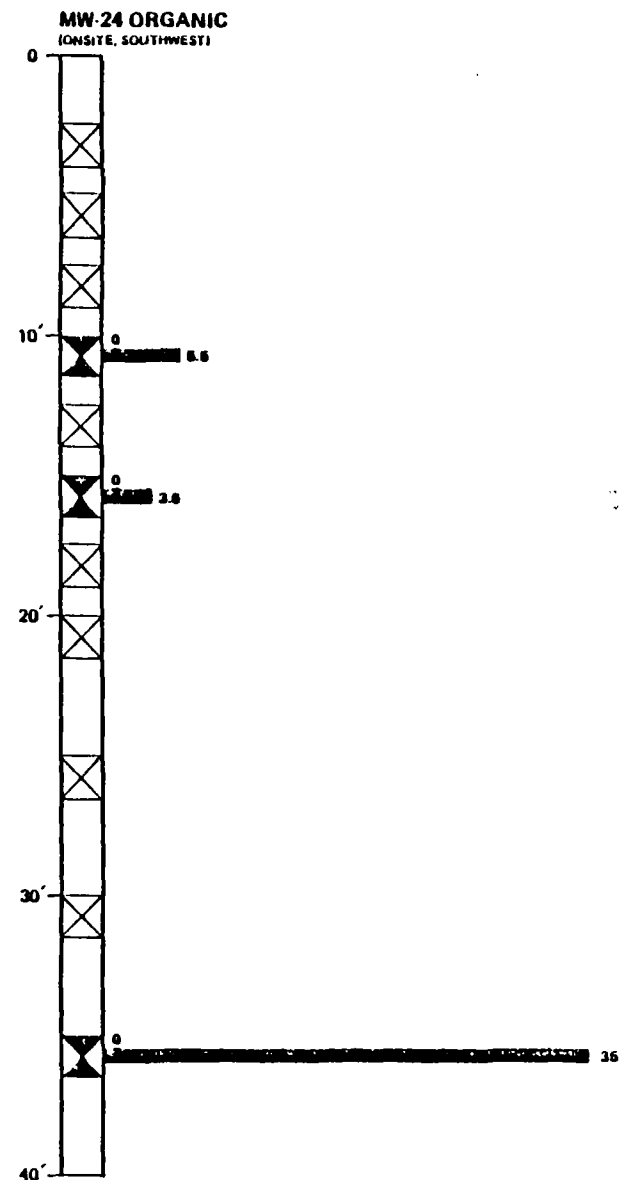
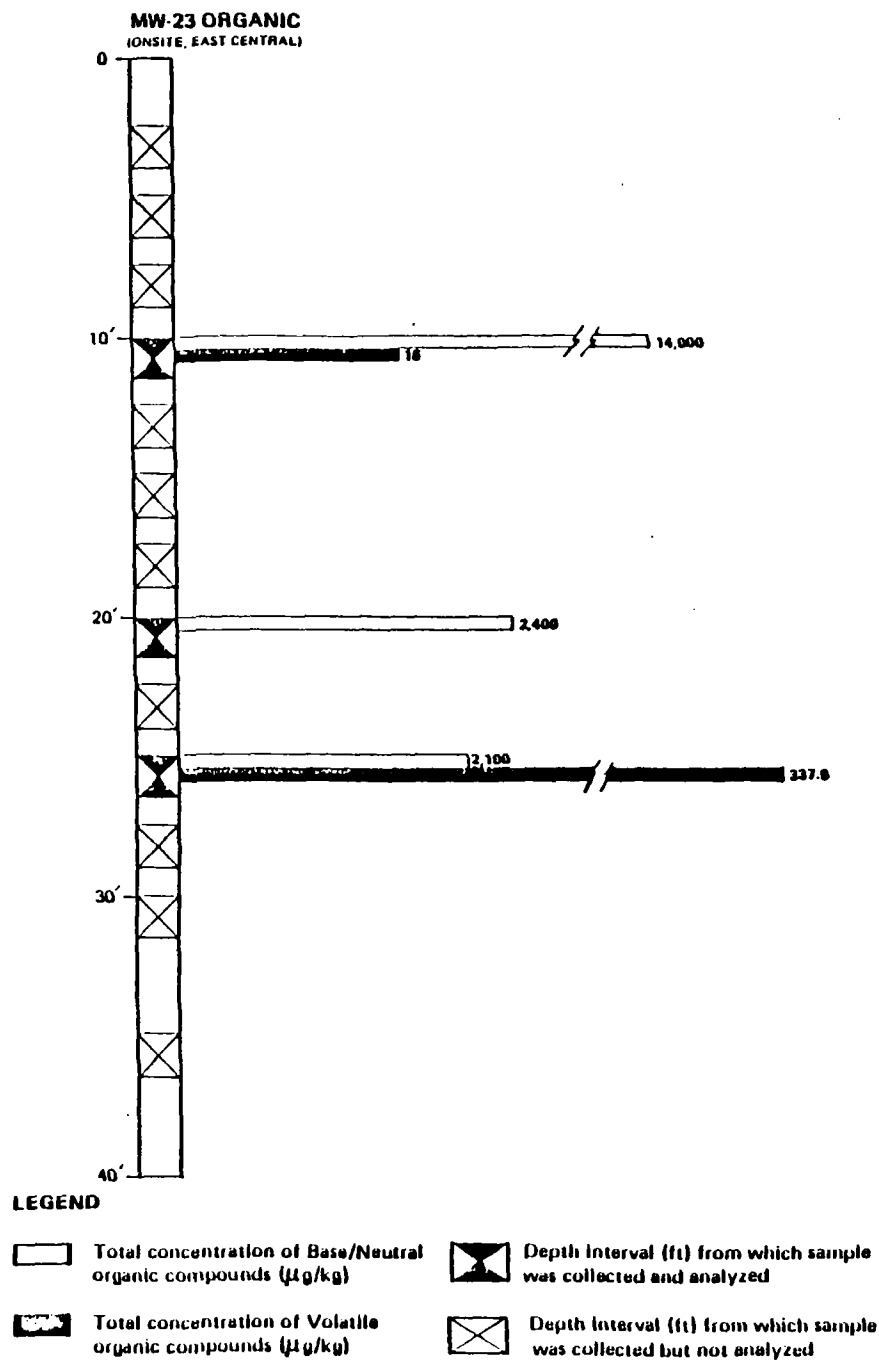
**FIGURE 10a**  
SUMMARY OF BASE/NEUTRAL AND  
VOLATILE ORGANIC ANALYSIS DATA  
FOR SURFACE SOIL SAMPLES  
CHEM - DYNE RI



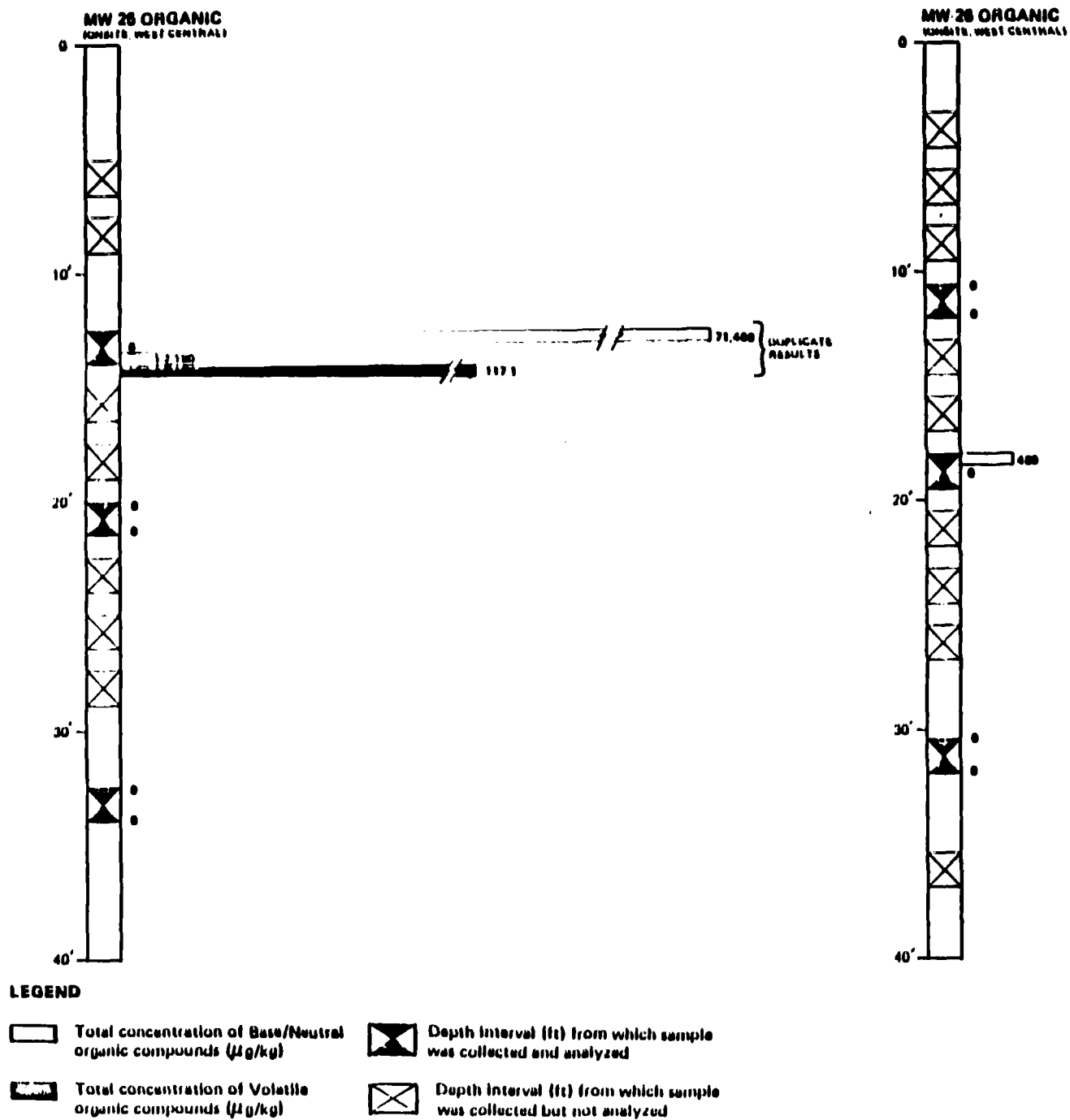
# LEGEND

-  Total concentration of Base/Neutral organic compounds ( $\mu\text{g}/\text{kg}$ )
-  Total concentration of Volatile organic compounds ( $\mu\text{g}/\text{kg}$ )
-  Depth interval (ft) from which sample was collected and analyzed

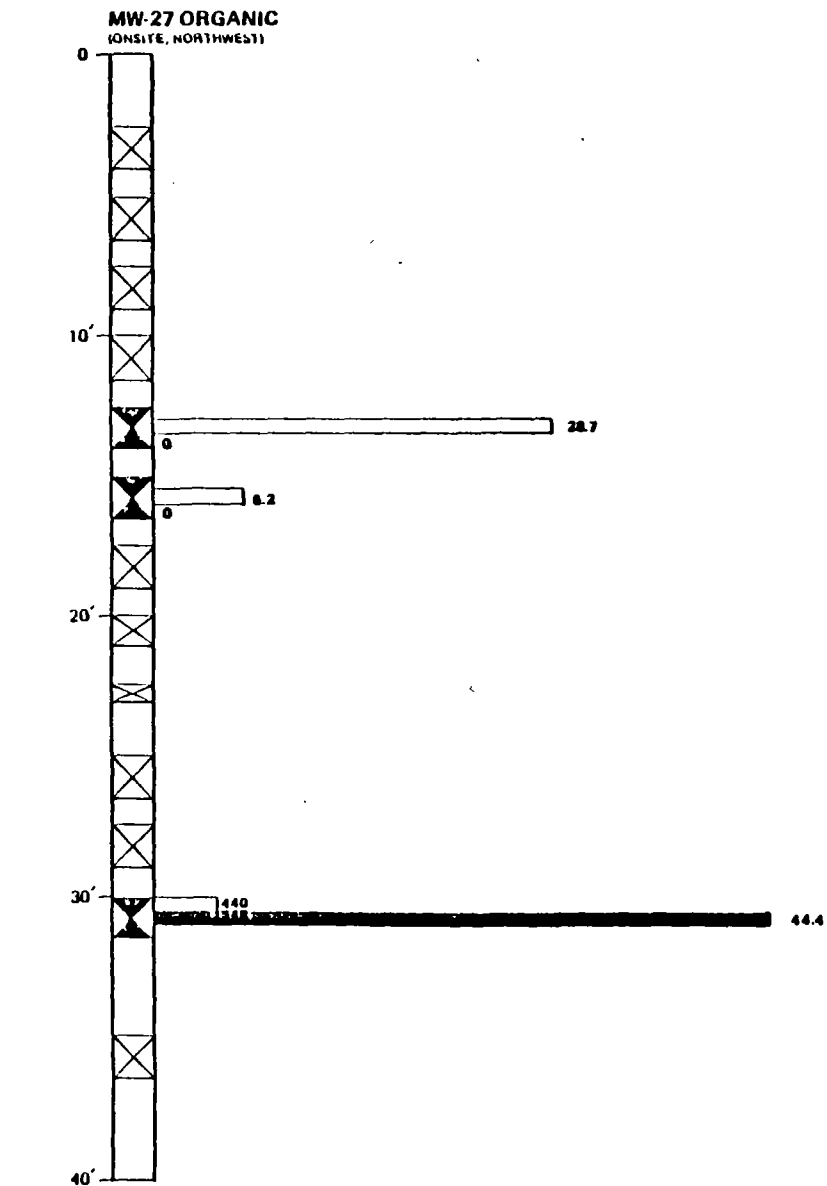
**FIGURE 10b**  
**SUMMARY OF BASE/NEUTRAL AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FOR SURFACE SOIL SAMPLES**  
**CIEM - DYNE RI**



**FIGURE 11a**  
**SUMMARY OF BASE/NEUTRAL AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FOR SUBSURFACE SOIL SAMPLES**  
CHEM - DYNE RI



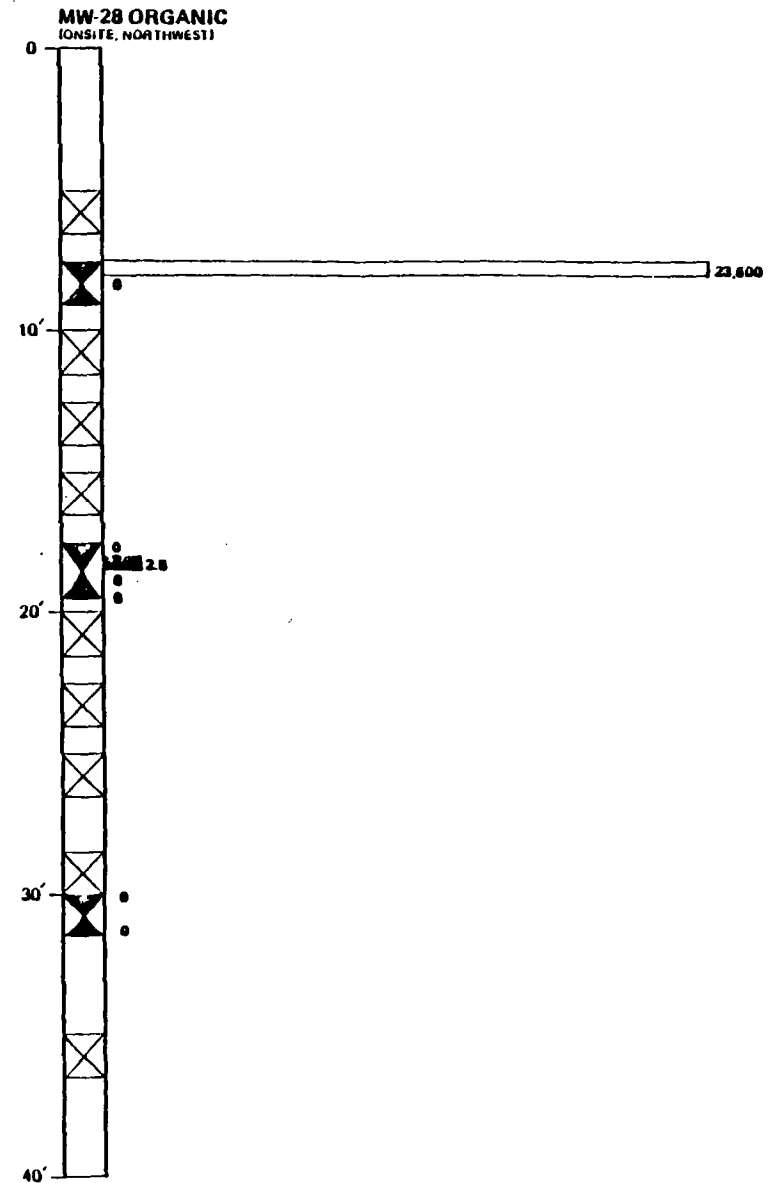
**FIGURE 11b**  
SUMMARY OF BASE/NEUTRAL AND  
VOLATILE ORGANIC ANALYSIS DATA  
FOR SUBSURFACE SOIL SAMPLES  
CIEM - DYNE RI



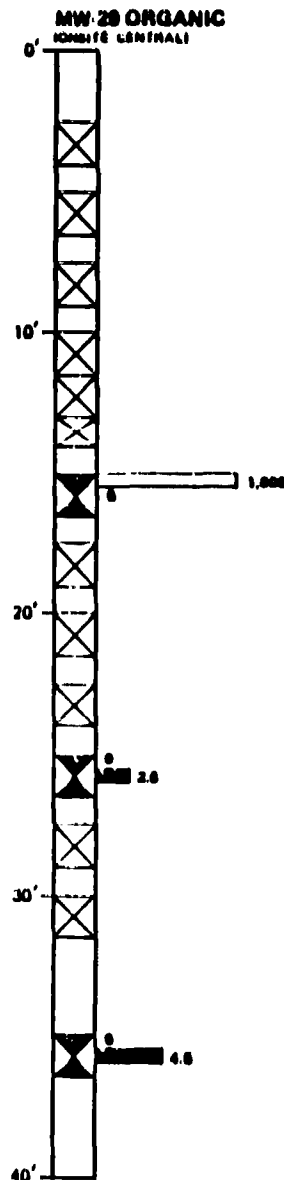
**LEGEND**

- Total concentration of Base/Neutral organic compounds (μg/kg)
- Total concentration of Volatile organic compounds (μg/kg)



- Depth Interval (ft) from which sample was collected and analyzed
- Depth Interval (ft) from which sample was collected but not analyzed





**FIGURE 11c**  
**SUMMARY OF BASE/NEUTRAL AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE RI

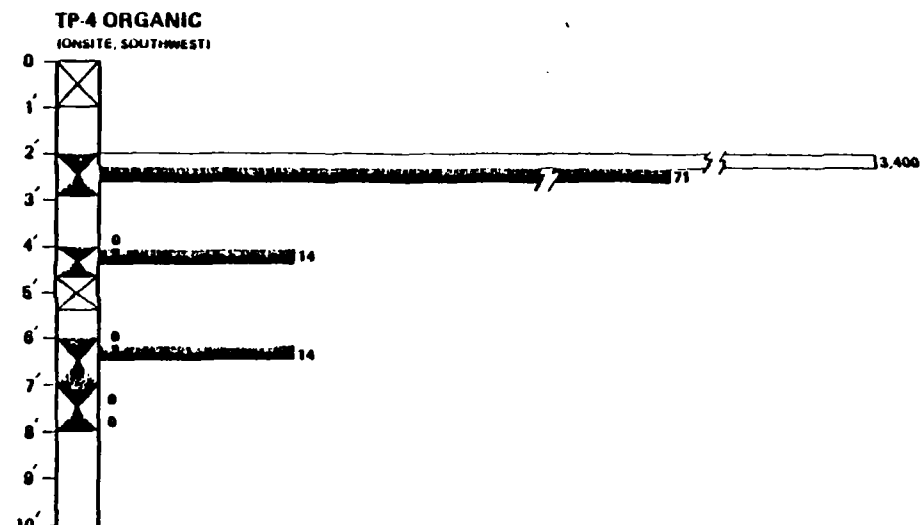
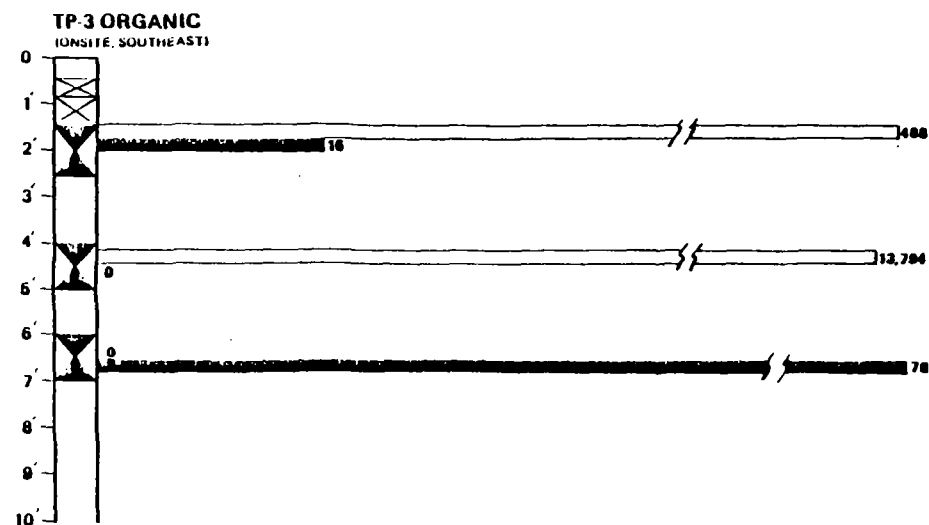
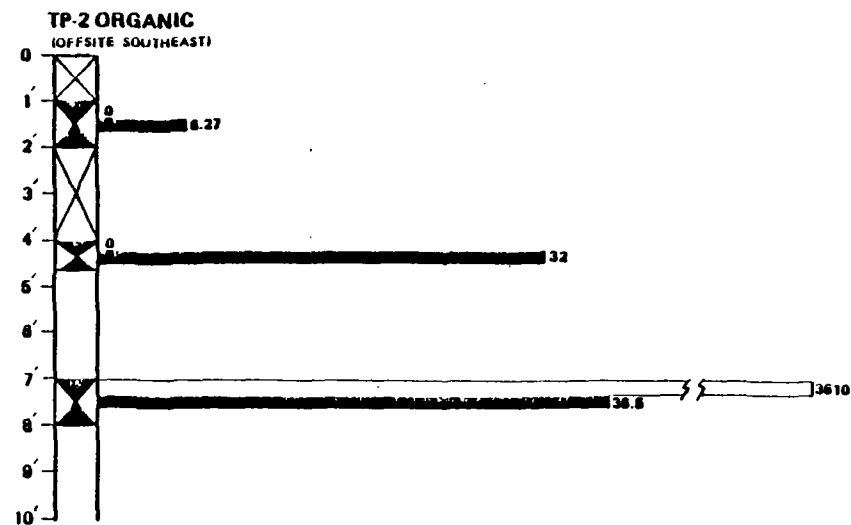
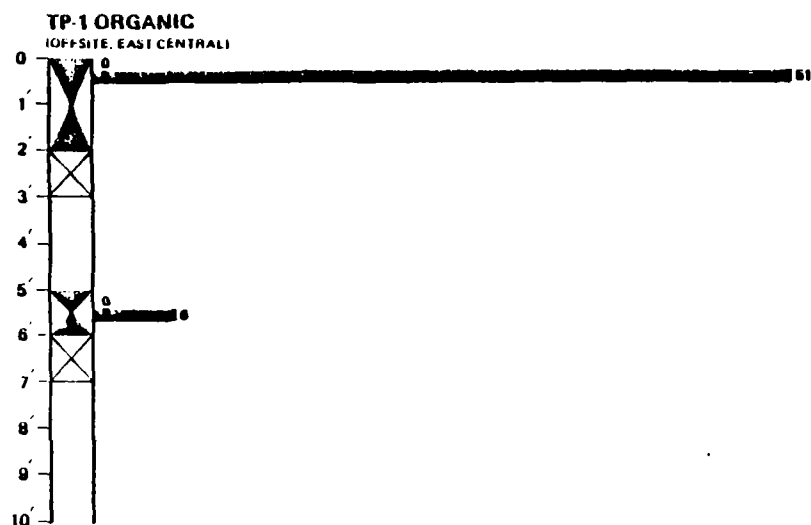


**LEGEND**

-  Total concentration of Base/Neutral organic compounds ( $\mu\text{g}/\text{kg}$ )
-  Total concentration of Volatile organic compounds ( $\mu\text{g}/\text{kg}$ )

-  Depth Interval (ft) from which sample was collected and analyzed
-  Depth Interval (ft) from which sample was collected but not analyzed

**FIGURE 11d**  
**SUMMARY OF BASE/NEUTRAL AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FOR SUBSURFACE SOIL SAMPLES**  
CIEM - DYNE RI



#### LEGEND

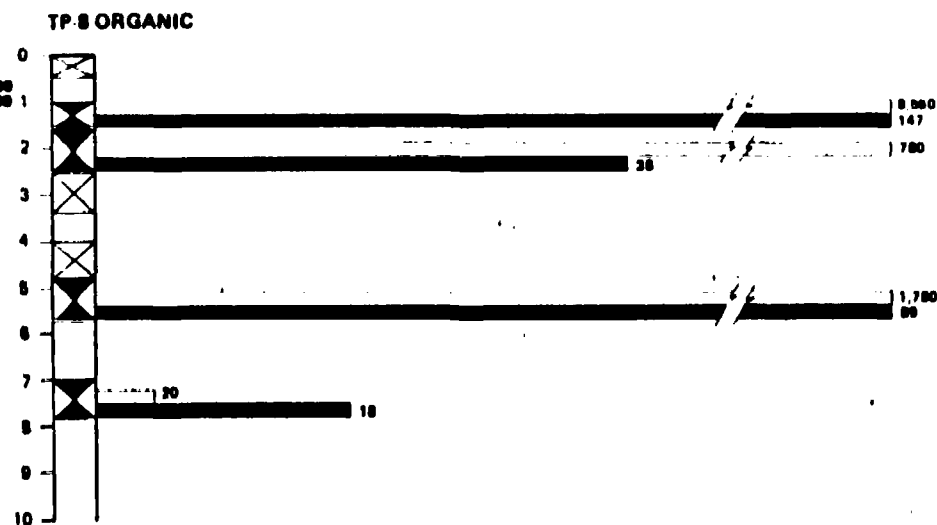
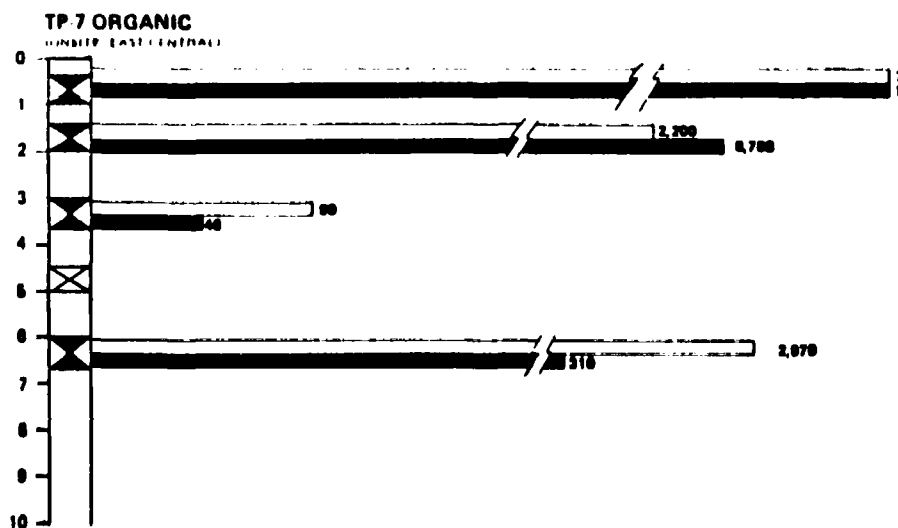
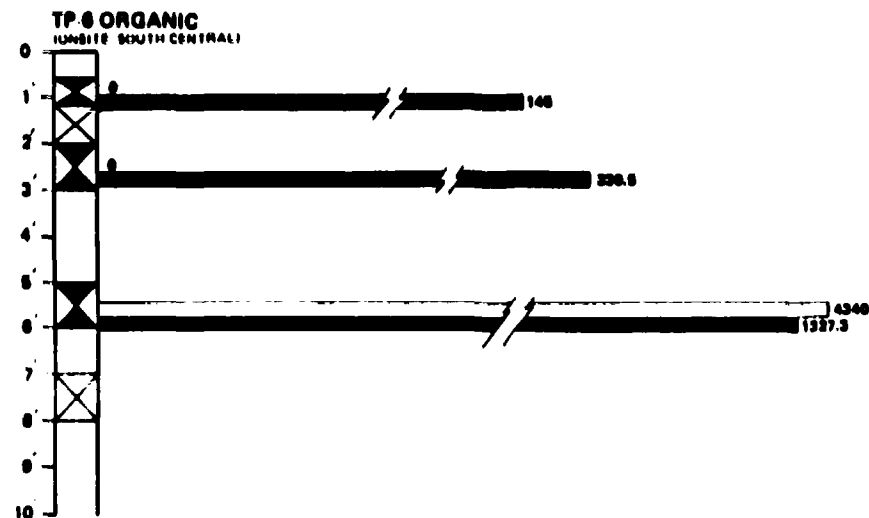
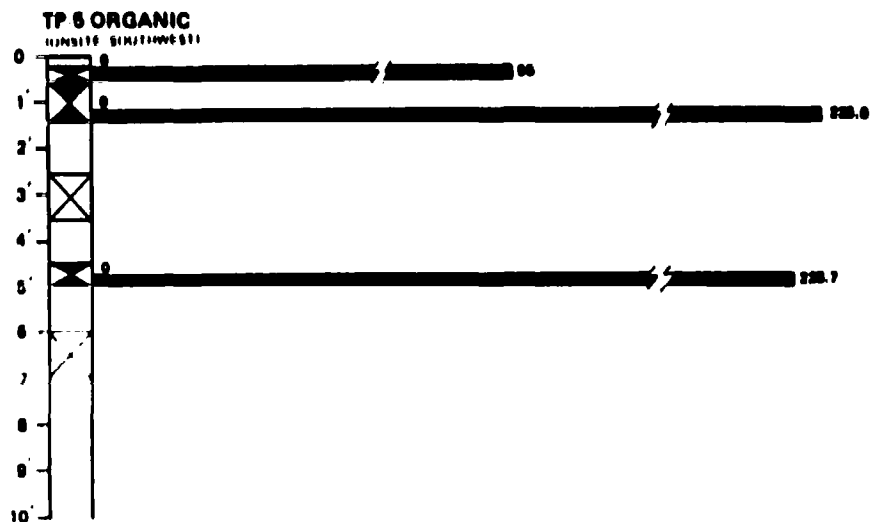
Total concentration of Base/Neutral organic compounds (μg/kg)

Total concentration of Volatile organic compounds (μg/kg)

Depth interval (ft) from which sample was collected and analyzed

Depth interval (ft) from which sample was collected but not analyzed

**FIGURE 11e**  
**SUMMARY OF BASE/NEUTRALS AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FOR SUBSURFACE SOIL SAMPLES**  
CHEM - DYNE HI



#### LEGEND

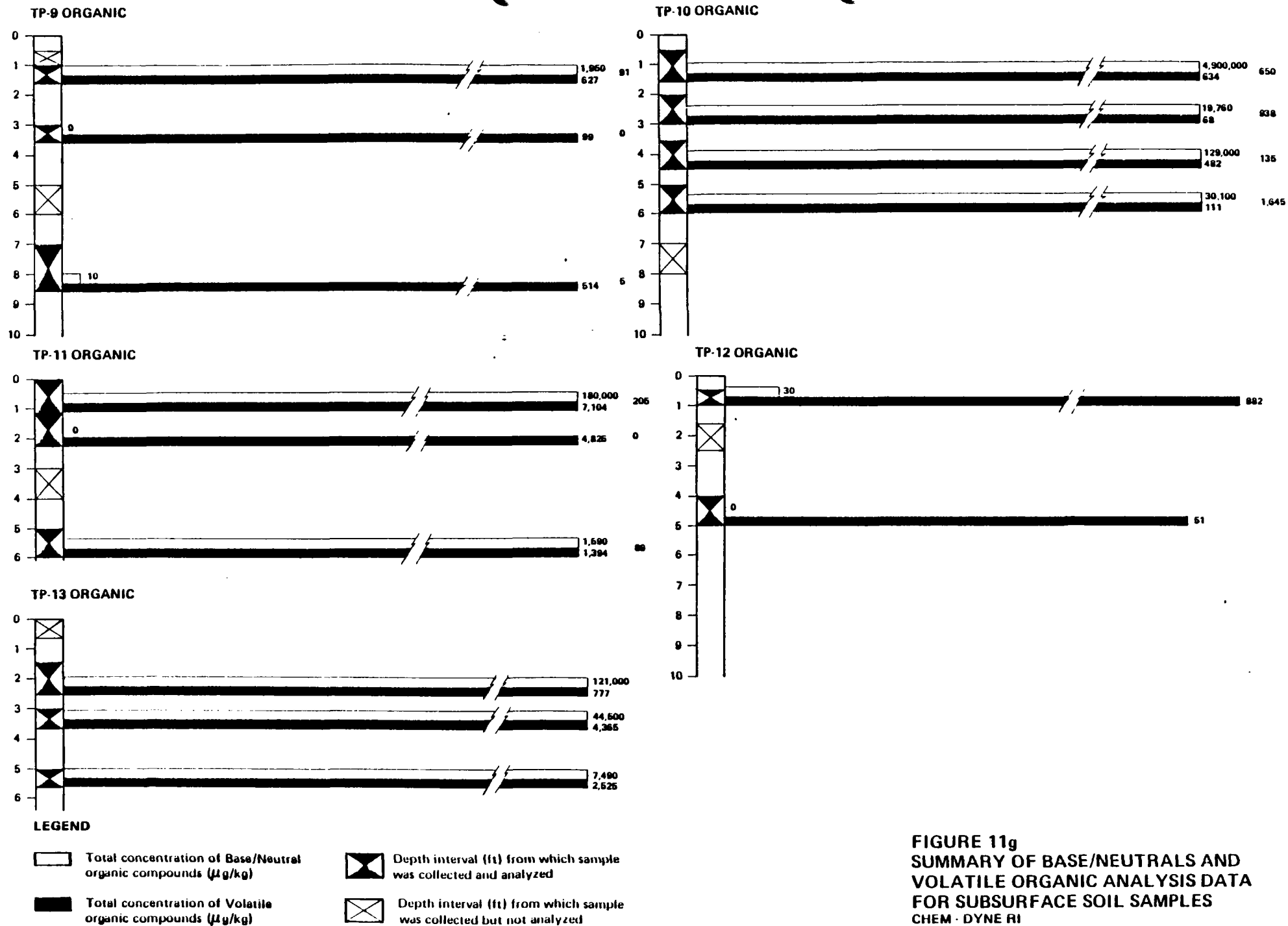
□ Total concentration of Base/Neutral organic compounds (μg/kg)

■ Total concentration of Volatile organic compounds (μg/kg)

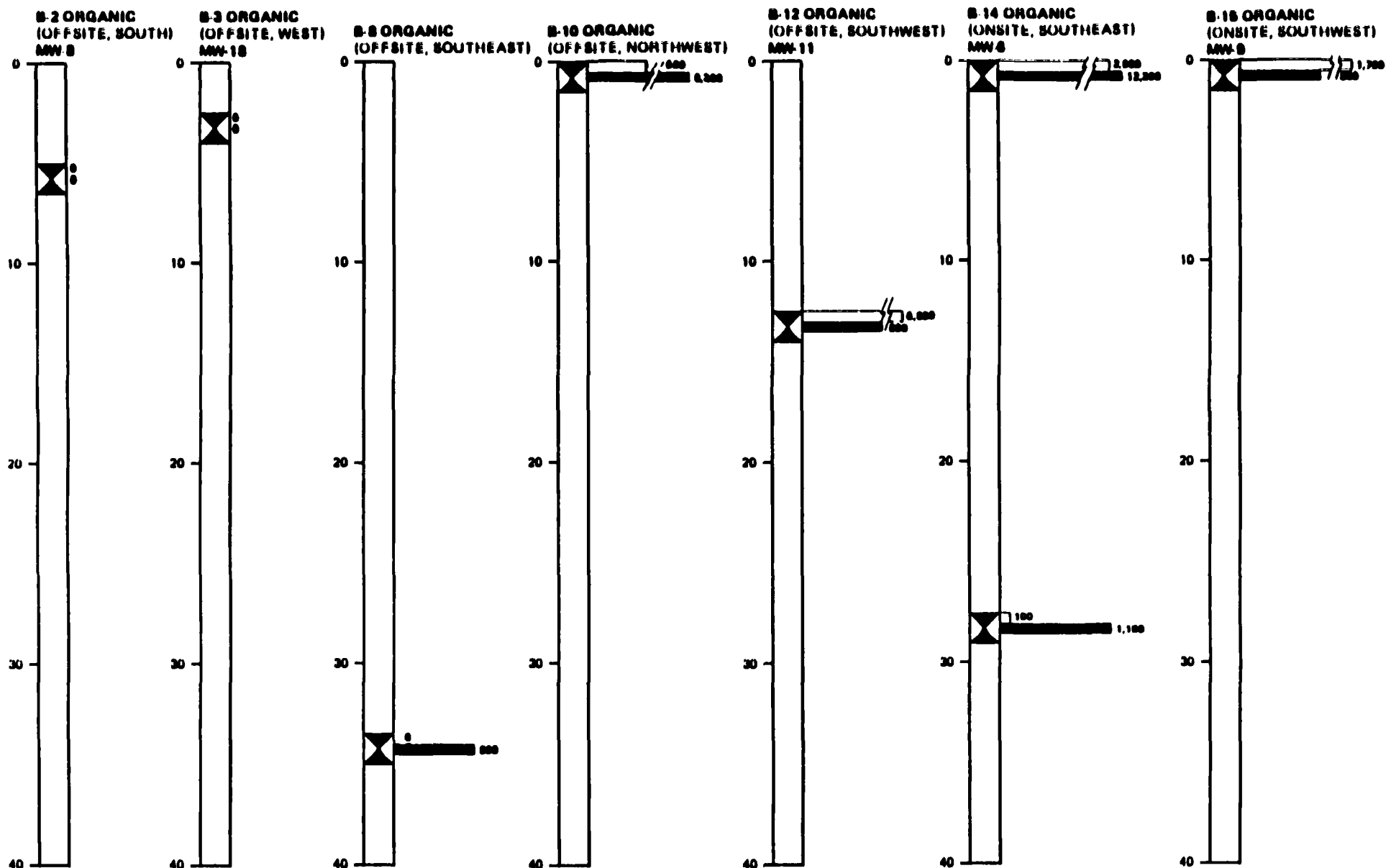
⊗ Depth interval (ft) from which sample was collected and analyzed

⊗ Depth interval (ft) from which sample was collected but not analyzed

**FIGURE 11f**  
**SUMMARY OF BASE/NEUTRALS AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FOR SUBSURFACE SOIL SAMPLES**  
CHEM - DYNE RI

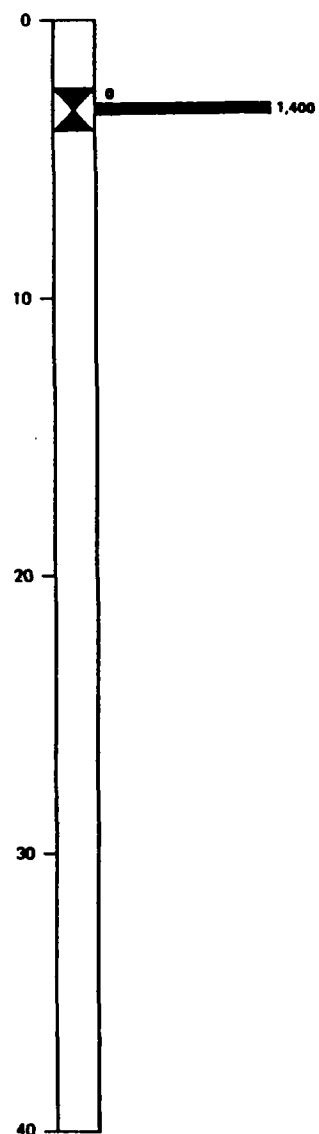


**FIGURE 11g**  
**SUMMARY OF BASE/NEUTRALS AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FOR SUBSURFACE SOIL SAMPLES**  
**CHEM · DYNE RI**

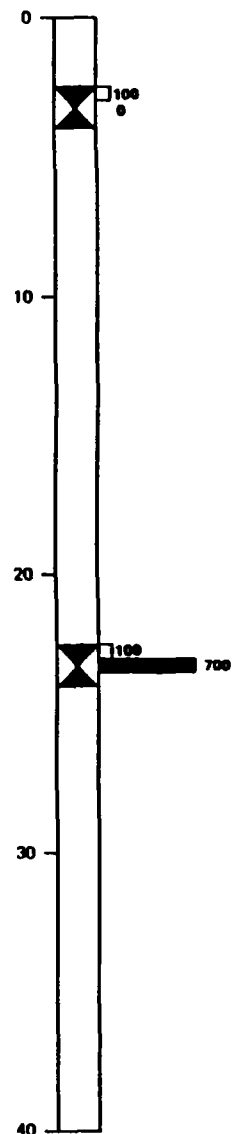


**FIGURE 12a**  
**SUMMARY OF BASE/NEUTRALS AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FROM SOIL BORING SAMPLES COLLECTED**  
**DURING FIT INVESTIGATION**  
**CIEM - DYNE HI**



**B-22 ORGANIC  
(BLUE WAREHOUSE LOT)**




**B-26 ORGANIC  
(OFFSITE, NORTHWEST)**



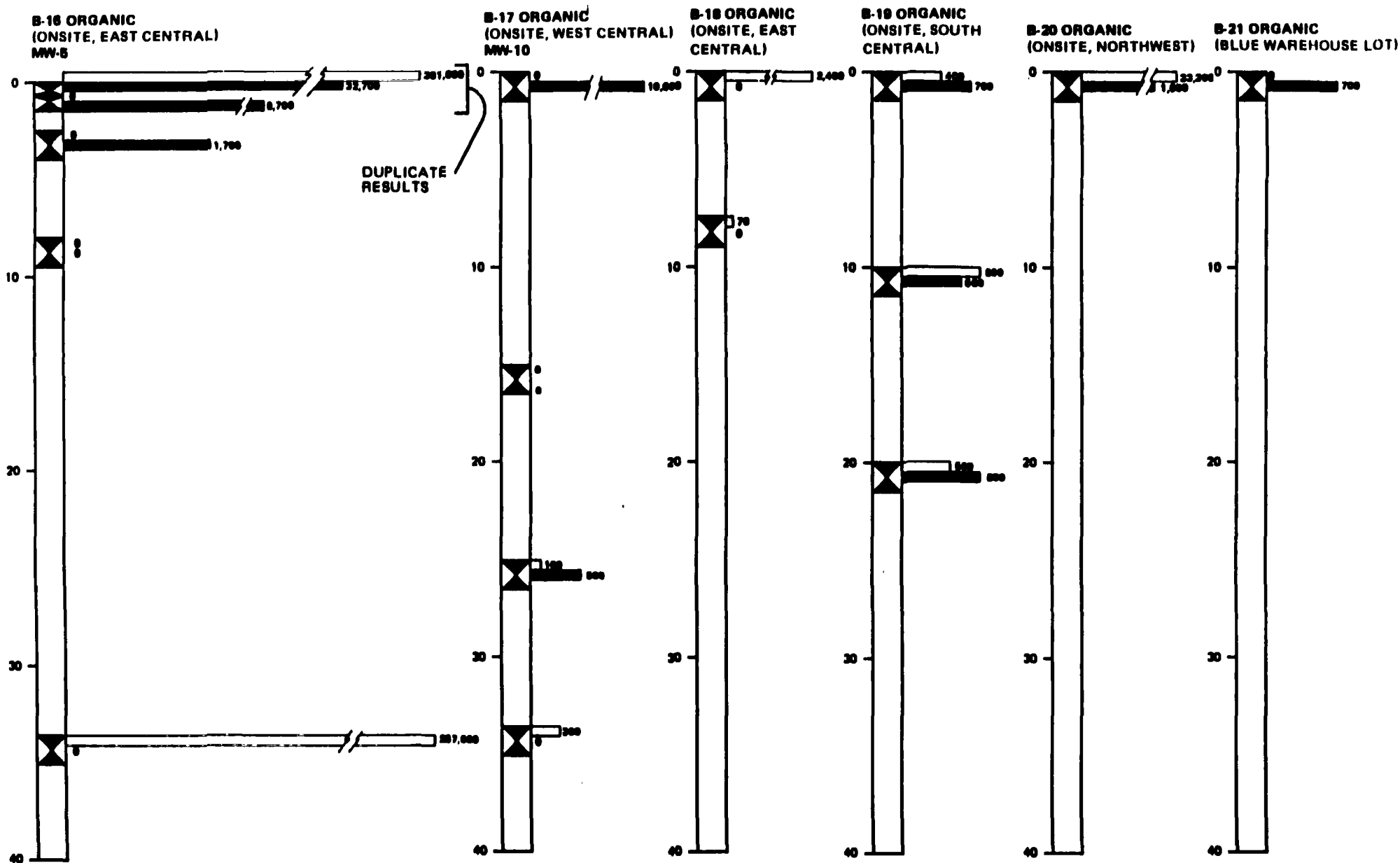
**LEGEND**

-  Total concentration of Base/Neutral organic compounds ( $\mu\text{g/kg}$ )
-  Total concentration of Volatile organic compounds ( $\mu\text{g/kg}$ )

-  Depth interval (ft) from which sample was collected and analyzed

NOTE: Concentrations are adjusted for "cross-contamination" and "baseline values" as determined in the FIT report.

**FIGURE 12C  
SUMMARY OF BASE/NEUTRALS AND  
VOLATILE ORGANIC ANALYSIS DATA  
FROM SOIL BORING SAMPLES COLLECTED  
DURING FIT INVESTIGATION  
CHEM - DYNE RI**



**FIGURE 12b**  
**SUMMARY OF BASE/NEUTRALS AND**  
**VOLATILE ORGANIC ANALYSIS DATA**  
**FROM SOIL BORING SAMPLES COLLECTED**  
**DURING FIT INVESTIGATION**  
 NE RI

## GROUNDWATER

### GROUNDWATER FLOW AND AQUIFER CHARACTERISTICS

The direction and velocities of groundwater flow in the vicinity of the Chem-Dyne site are dependent on the aquifer properties; transmissivity and storage coefficient, and on the location of recharge and discharge areas and gradients. Vertical and horizontal gradients in the area were determined by measuring the water levels in each of the monitoring wells prior to collection of the water quality samples during April, June-July, and October 1983. The relevant aquifer parameters were evaluated in October 1983, by conducting an aquifer pump test. This section of the RI report will discuss the methods and results of the pump test and interpretations of groundwater flow.

#### Physical Characteristics of the Aquifer

Geology. The geologic materials underlying the Chem-Dyne site are a highly variable mixture of sands, gravels, silts and clays deposited by glacial melt waters from receding continental ice sheets. Interglacial streams and rivers cut deeply into the bedrock of the area and, as the ice receded and the flows lessened, deposited the materials that now make up the aquifer. The aquifer generally follows the course of the present Great Miami River. It is approximately 2 miles wide and is bounded on both sides by steep walls of bedrock. Its thickness is variable but generally around 150 feet to 200 feet.

Because of the variable nature of stream deposition, the aquifer materials are highly variable as well. Coarse gravels and cobbles were encountered in some of the borings while others encountered silt to silty clay lenses. No consistent confining beds were detected throughout the area. Smith (1960) reported a continuous clay unit whose eastern boundary is apparently to the west of the Chem-Dyne site. Wells MW-12, MW-13 and a soil boring 400 feet north of MW-13 encountered a gray silt/greenish sandy, silty clay that could act as a low permeability unit. Wells MW-8 and MW-9 also encountered this silt/clay deposit but MW-10 and MW-11, between MW-12 and MW-9, did not encounter this silt/clay. Figure 3 illustrates where this silt/clay unit is present.

The bedrock slopes downward toward the Great Miami River causing the aquifer to increase in thickness in a northwest direction and thinning toward the southeast. Figures 2A through 2D and Figure 3 illustrate the geologic material comprising the aquifer.

Aquifer Hydraulic Properties. The ease with which water is able to move through an aquifer is dependent on the permeability or hydraulic conductivity of the aquifer materials. The hydraulic conductivity times the aquifer thickness is the transmissivity of the aquifer. This property varies with changes in the aquifer materials. The preceding discussion on the variability of these aquifer materials indicates that the hydraulic conductivity will also be variable in both vertical and horizontal directions.

The amount of water released from a column of aquifer with unit cross section under a unit decline in head is the storage coefficient. For a water table aquifer it is essentially the connected porosity of the geologic materials minus a small volume termed the specific retention. For a confined aquifer it is a product of the expansion of the water and compression of the aquifer materials. Typical values for an unconfined aquifer are 0.1 to 0.3; for a confined aquifer, 0.01 to 0.00005 are typical values.

An aquifer pump test was conducted on October 30 to 31, 1983, at the Chem-Dyne site to derive values for the hydraulic conductivity, transmissivity and storage coefficient. A discussion of the test methods is included in the technical memorandum for Subtask 3-3.5 in Volume 2 of 2. Factors affecting the pump test results and interpretations of these results are discussed here.

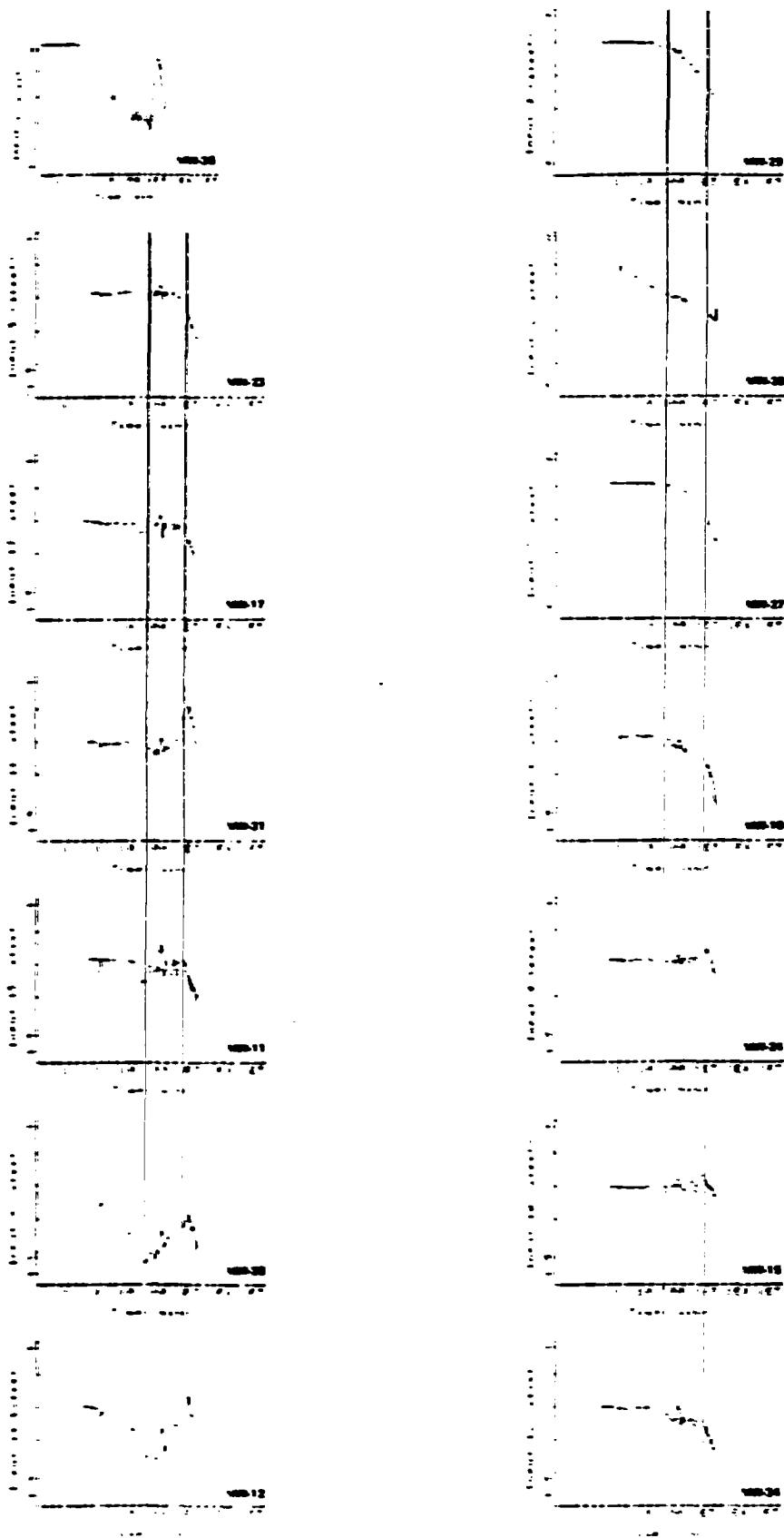
Factors Affecting the Test Results. There are a variety of methods for conducting aquifer pump tests. The procedures employed at the Chem-Dyne site were to pump the test well at a known constant rate for a specified time while measuring the decline in water levels in the test well and in surrounding monitoring wells. By knowing the depth and distance of each monitoring well from the test well, it is possible to apply non-equilibrium well hydraulics equations to derive values for transmissivity, storage coefficient and vertical hydraulic conductivity. The test procedures were conducted in general accordance to the discussion provided by R. W. Stallman (1971). The methods of analysis of the data employed several techniques but in general followed the procedures described by S. W. Lohman (1972).

Any outside influences that cause fluctuations in the water levels in the monitoring wells or test well during the test will result in some ambiguity of the test results. Although all outside influences cannot be identified, several of the most obvious are discussed below.

- o On the northeast of the test area is the Ford Canal and on the west and northwest is the Great Miami River. Changes in the water levels in these surface sources could cause a rise or drop in

nearby wells. Changes in water levels were monitored during the test at a concrete outflow structure 100 feet upstream in the Ford Canal from the confluence of the Ford Canal and the Great Miami River. Total changes in head at this point during the test were less than 0.1 foot. Well MW-3 near the Ford Canal hydraulic structure recorded a general rise in water level beginning mid-way through the test and continued until the recorder was removed. This change in level may have been related to changes in the Ford Canal. The water level in the Ford Canal was not monitored during the test.

- o Barometric pressure fluctuations can affect water levels in wells penetrating confined aquifers. Changes in barometric pressure during the time the test was in process were recorded by the National Weather Service at the airport. Barometric pressure showed a gradual decline throughout the entire period of the test. No changes in water levels in the wells can be specifically related to the barometric pressure changes.
- o Compression of the aquifer by heavily loaded trains passing nearby monitoring wells can cause fluctuations in well water levels. A record of the time each train passed during the test was recorded and is included in the technical memorandum for the pump test. The magnitude of fluctuation in water levels related to trains would be expected to be only a few hundredths of a foot. None of the observed water level fluctuations were able to be directly related to the trains.
- o Pumping wells or injection wells in the vicinity of the test could markedly affect water levels in both the test wells and monitoring wells. Inspection of the continuous water level records acquired during the test showed several peaks or changes in water levels that could be related to nearby wells. These are shown in Figure 13. Known nearby pumping wells include the wells for the City Electric Plant, the Champion Paper Company, Becket Paper Company, and the Mercy Hospital cooling water wells. The fluctuations of water levels indicated on the charts reflect a pump or pumps that are cycling ON and OFF. In addition the affect was seen more strongly in the deep wells than the shallow wells. Well MW-15 is located closest to the City Electric Plant and should, therefore, react to the cities wells more than other wells more distant. This was not



NOTE: LINES SPECIFIED BY DATE. THE GRAPH  
 PRESENTS A SUMMARY OF DATA FOR THE

FIGURE 13  
 TIME-DRAWDOWN RECORDS FOR  
 SELECTED MONITORING WELLS  
 (Continued)

of  $1 \times 10^5$  gpd/ft to  $3 \times 10^5$  gpd/ft. Higher values of transmissivity are generally toward the west and southwest.

- o Groundwater flow directions are across the site and downward from the area near well Nos. MW-1, MW-2, and MW-3 toward the west and southwest. Higher transmissivity values near the river and higher values of transmissivity parallel to the river may divert flow more toward the south. Conversely, strong vertical flow components and the impact of the Champion Paper Company's wells on the west side of the river indicate groundwater flow is moving to the west underneath the river. The direction of movement of the contaminated groundwater plume indicates westward and downward flow beneath the site and toward the Champion wells is the predominant direction of flow. However, the lack of sampling points in the southwest area and in the deeper portions of the aquifer do not allow the alternate more southerly flow path to be evaluated in detail.
- o Rates of groundwater flow based on an assumed porosity (N) of 0.30, a gradient (I) of 0.002 and an average hydraulic conductivity (K) of 1,100 gpd/ft<sup>2</sup> or 147 ft/day are:  $U = KI/N = 0.98$  ft/day. If the porosity and gradient are assumed to be relatively constant the greatest range of transmissivities provides for a range of groundwater velocities from 0.15 ft/day to 3.5 ft/day. Because of the limitations on the data from the pump test the upper and lower bounds for this range are suspect. The most reliable data indicate the range for groundwater velocities is between 0.5 ft/day to 1.5 ft/day. Travel times for contaminants moving at the same velocity as the groundwater to a potential receptor well 3000 feet away would then be between 5 to 16 years. The Beckert Paper Company, Mercy Hospital, and Chamption wells are all within this 3,000 foot radius from the site and could potentially be affected by contaminated groundwater.

GLT461/14

## CHEMICAL ANALYSIS DISCUSSION

### Summary of Groundwater Sampling

During the RI, groundwater was sampled in three episodes. The first sampling effort (Phase I) in April 1983 included 22 monitoring wells that had been previously installed by FIT (E&E) and Roy F. Weston, Inc. The second sampling round (Phase II) in June and July 1983 covered the original 22 wells plus 7 new onsite wells installed under this contract. The final sampling work (Phase III) in October 1983 included the previous 29 wells plus 7 new offsite wells installed under this contract. Details of the well sampling and installation are in TM's for Task 3-1, Task 3-2.3, Task 3-3.2, and Task 3-3.3 in Volume 2 of 2. Locations of the monitoring wells are shown in Figure 16, shown in this report.

In this discussion, upgradient or background monitoring wells are MW-1, MW-2, and MW-3. These three wells are east and upgradient of the site. Where appropriate, chemical concentrations for inorganic and organic constituents are compared with values determined in samples from these upgradient wells.

Two groupings of wells are referenced in this report, perimeter wells and fringe wells. The perimeter wells are the wells at the limits of monitoring the network. The perimeter wells are as follows:

MW-1	MW-19
MW-2	MW-20
MW-3	MW-21
MW-8	MW-22
MW-16	MW-32
MW-17	

Fringe wells refer to the monitoring wells which define the location of the edge or fringe of a contaminant plume. The actual set of wells included in this category is specific to the contamination being considered.

In addition to the monitoring well samples, several active industrial and municipal production wells were sampled during each sampling effort. These production wells included the following:

- o Vaughn Building Company
- o Hamilton Electric Power Well No. 9
- o Beckett Paper Parking Lot and Dayton Street Well
- o Champion Paper Well Nos. 1, 4, and 9
- o Hamilton City Well No. 11

Locations of these and all other known inactive or abandoned production wells are shown in Figure 17. Descriptions of these wells are in the final section of the Task 1 TM in Volume 2 of 2.

#### Summary of Groundwater Analysis

Chemical analysis of groundwater samples consisted of the following:

- o Routine inorganic analysis package Task 1 and 2 including cyanide from the U.S. EPA contract laboratory program (CLP). Tasks 1 and 2 metals water samples were field filtered with 0.45 micron filters so metals data is the "soluble" fraction except where noted.
- o Routine organic analysis package from the U.S. EPA CLP.

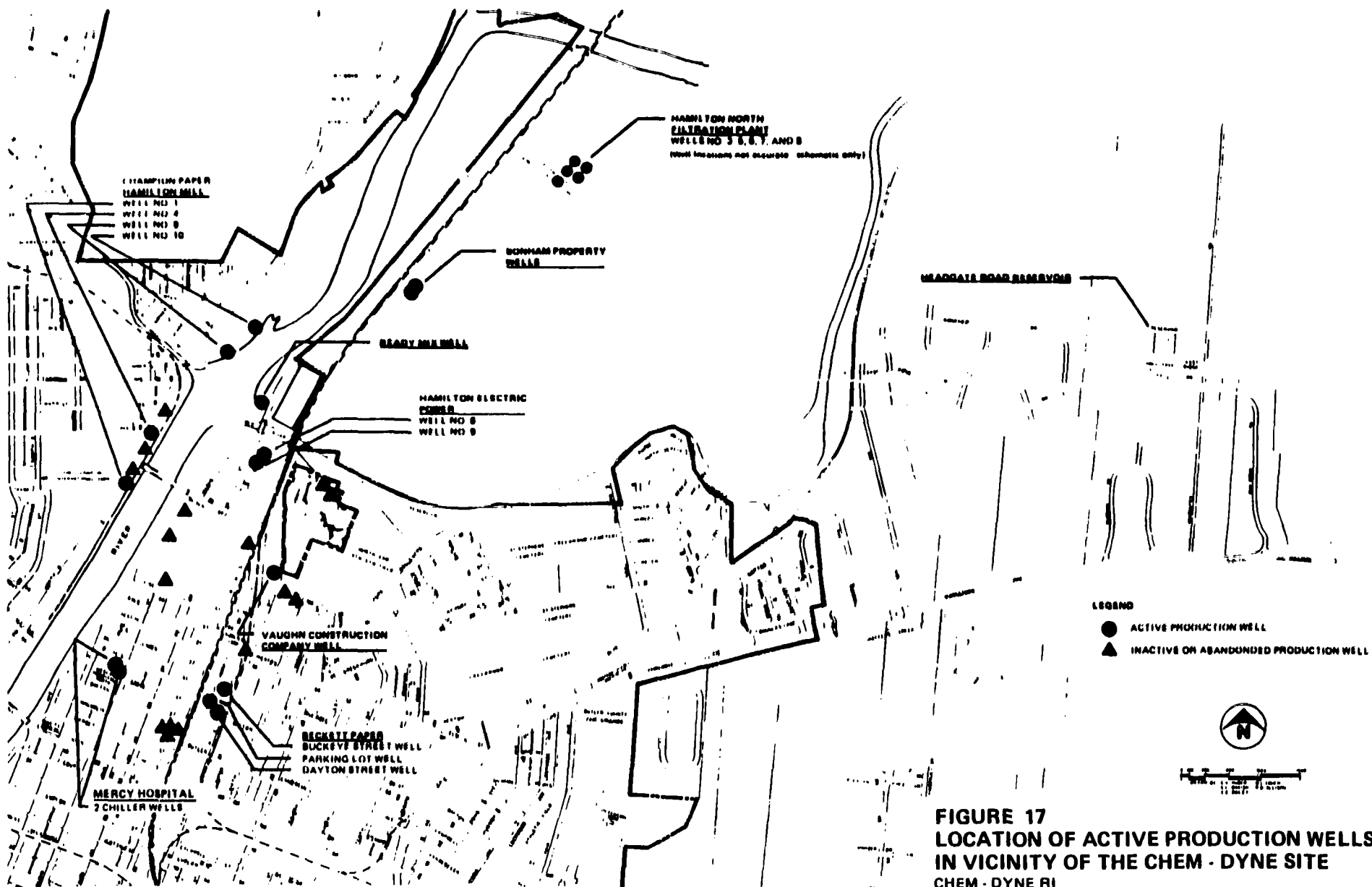
A few samples taken from production wells at Beckett Paper and Champion Paper during Phase III were analyzed for volatile organic compounds (VOC) only. These samples were taken concurrent with sampling by a representative from FMC Corporation.

Complete summaries of all analytical data are presented in the following TM's in Volume 2 of 2 of this report.

<u>Sampling Effort</u>	<u>Reference TM</u>
Phase I	Task 3-1
Phase II	Task 3-2.4
Phase III	Task 3-3.3

#### Inorganic Contamination

Analytical data revealed a general pattern of higher soluble barium, iron, manganese and boron concentrations in the vicinity of the site with concentrations tending to be lower in all monitoring and production wells farthest from the site. Upgradient soluble barium, iron, manganese, and boron concentrations are tabulated below, calculated as the average concentration for the three upgradient wells over the three most recent sampling events:



<u>Element</u>	<u>Calculated Average Soluble Concentration, ug/L<sup>a</sup></u>
Barium	137 ± 8
Iron <sup>b</sup>	854 ± 1,547 <sup>c</sup>
Manganese	58 ± 70
Boron	185 ± 136

<sup>a</sup> Arithmetic average of concentrations in samples from MW-1, MW-2, MW-3 with standard deviations.

<sup>b</sup> Average excludes the concentration of 7,800 ug/L measured in the Phase I sample from MW-3 because this sample was not filtered prior to preservation with nitric acid.

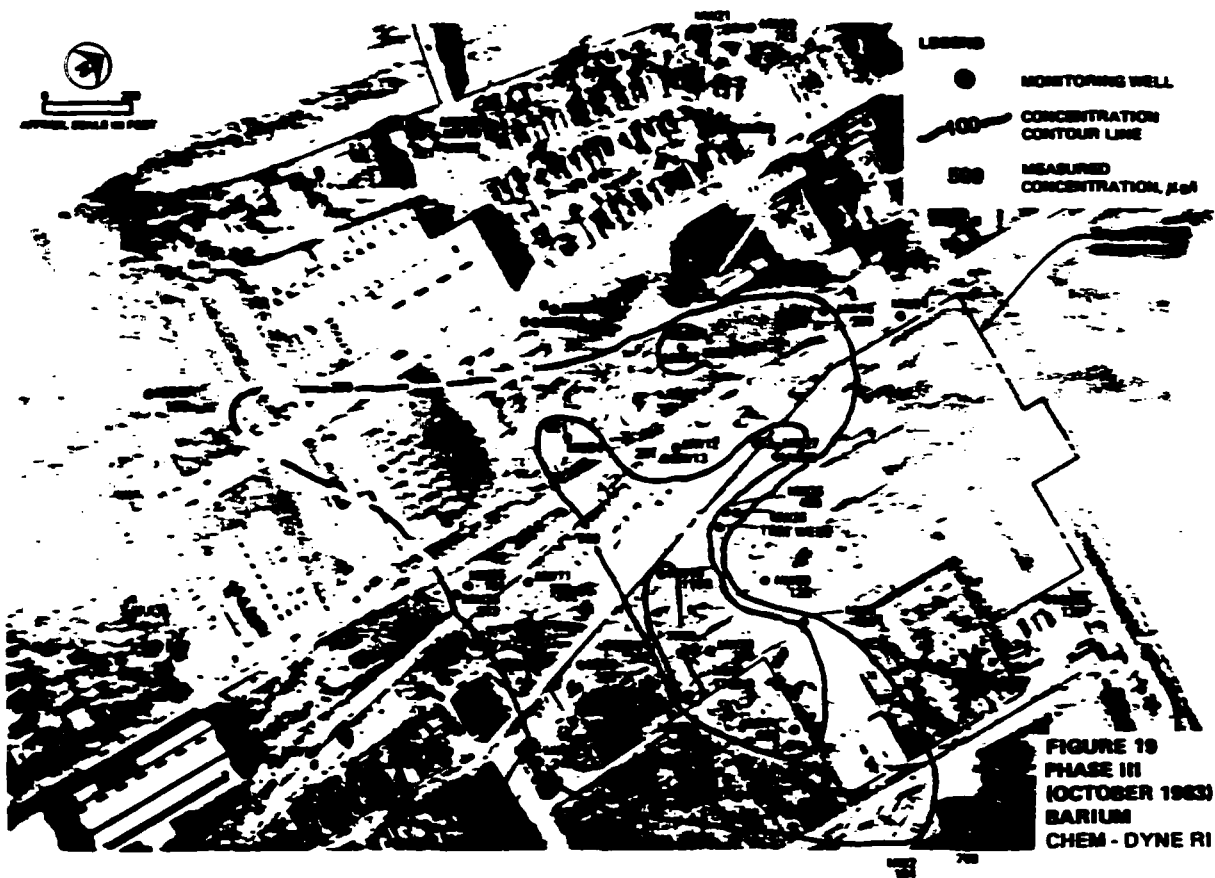
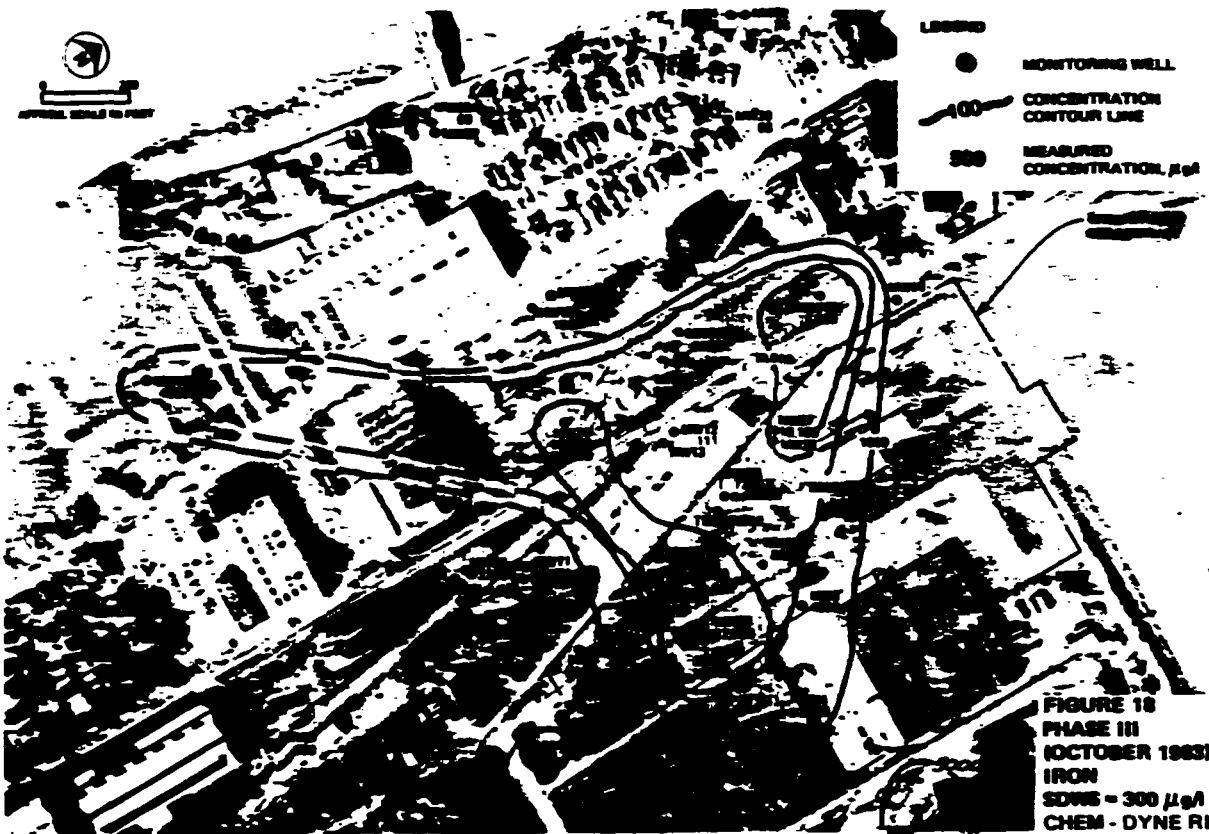
<sup>c</sup> Typical concentration range was 50 to 150 ug/L. However, at MW-2, 2,200 and 4,540 ug/L were measured in Phase I and Phase III samples respectively.

To compare these background concentrations for barium, iron, manganese, and boron with Phase III data, refer to Figures 18, 19, 20 and 21 which show the concentrations of these elements in each shallow well and general concentration contours. Each element shows concentration increases nearer the site.

The concentration variation of soluble aluminum and zinc appeared more random and less related to the site. Scattered local areas of high concentrations were observed. Large concentration variations were also noted between the sampling episodes. Other elements were not detected (or were found at or near detection limits) and did not show a pattern of contamination.

To evaluate the significance of inorganic concentrations found, all data were compared to the Interim Primary Drinking Water Standards (IPDWS). Three elements, barium, lead, and mercury were found to exceed IPDWS concentration limits as summarized in Table 15.

Mercury was found in high concentrations at four locations, well MW-11 in Phase I and wells MW-4, MW-13, and MW-19, wells during Phase III as shown in Table 15. The pattern of mercury data is difficult to interpret. The highest concentrations occurred in the Phase III samples. Two Phase III samples had mercury concentrations which were over 100 times greater in magnitude than concentrations measured in the two previous sampling phases (60 ug/L compared with previous concentrations of less than 0.2 ug/L).



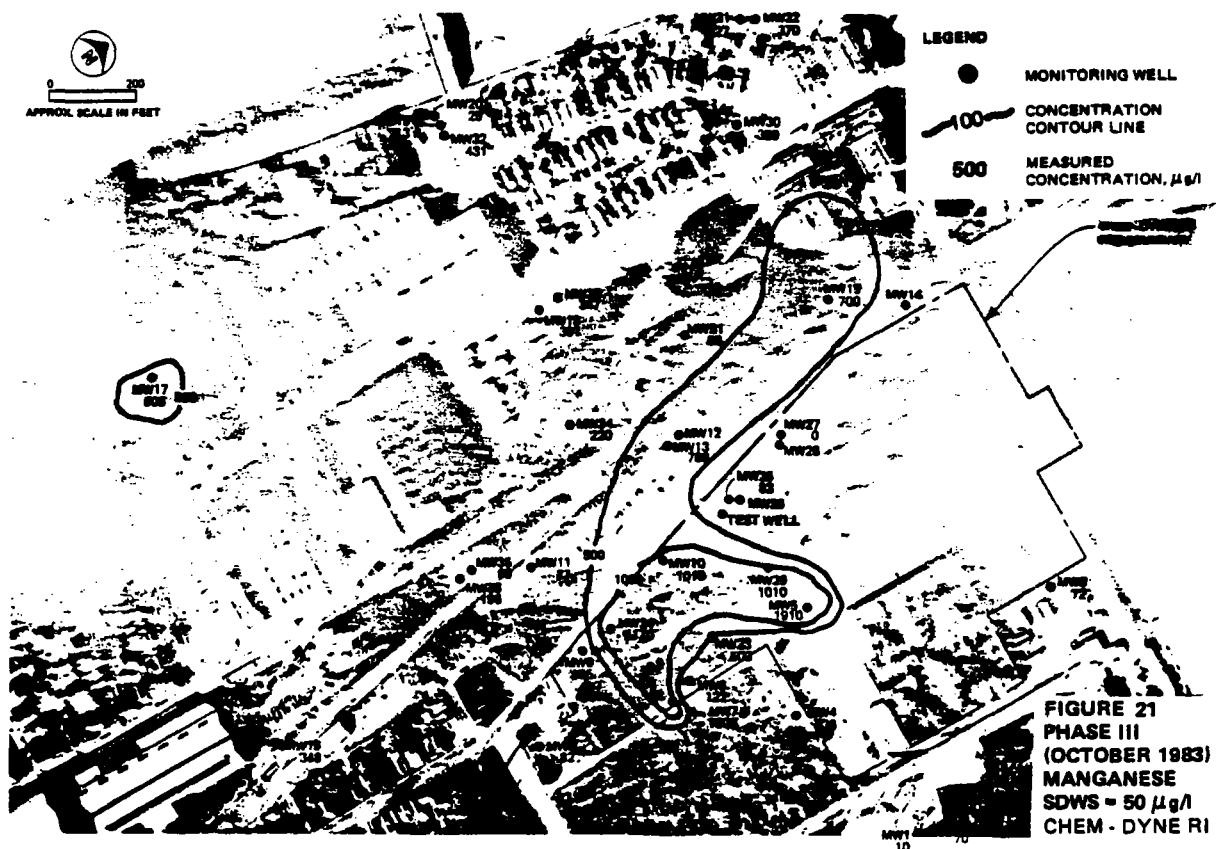
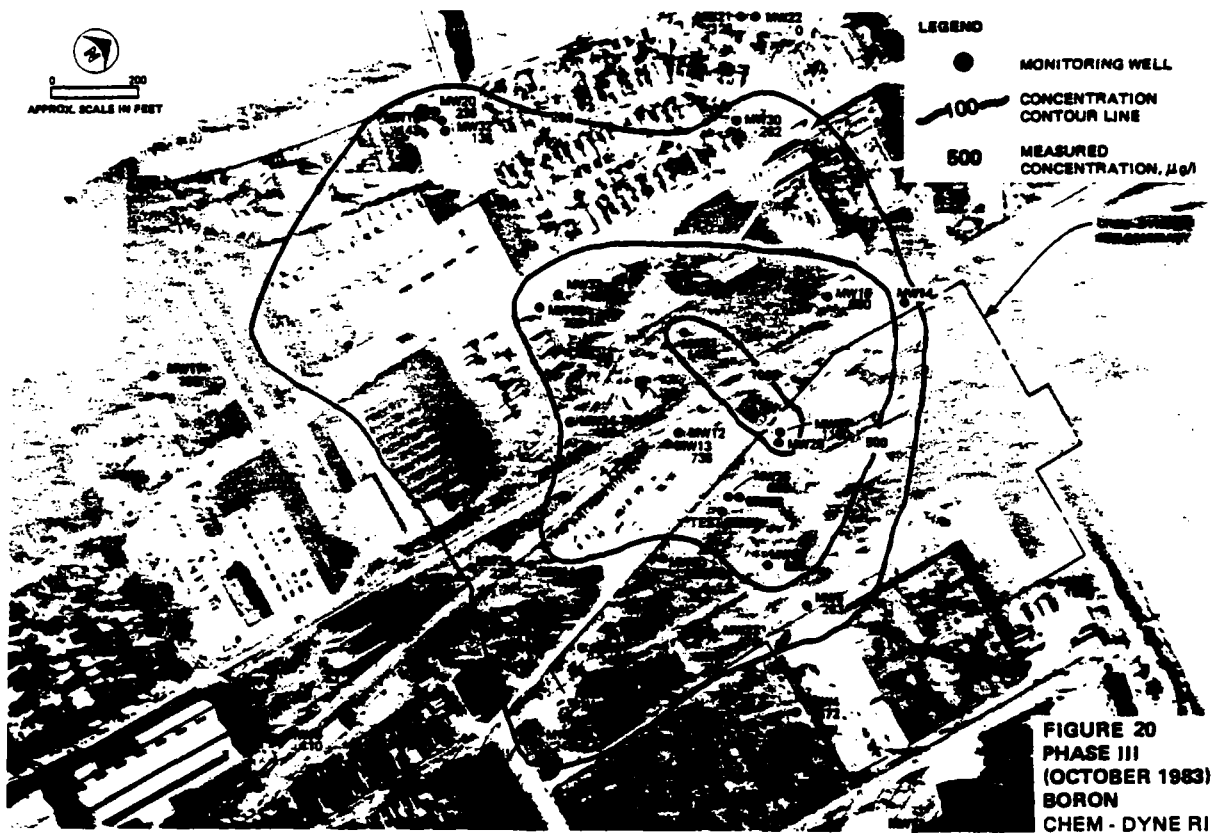


Table 15  
SUMMARY OF INORGANIC ANALYSIS DATA FOR ELEMENTS  
EXCEEDING INTERIM PRIMARY DRINKING WATER STANDARDS (IPDWS)

<u>Sampling Phase</u>	<u>Monitoring Well</u>	<u>Element</u>	<u>Soluble Concentration, ug/l</u>	<u>IPDWS, ug/l</u>
Phase I	MW-12	Barium	1,600	1,000
	MW-12	Barium	1,700	1,000
	MW-3	Lead	96	50
	MW-11	Mercury	2.5	2.0
Phase II	MW-12	Barium	1,930	1,000
Phase III	MW-6	Barium	1,100	1,000
	MW-10	Barium	1,180	1,000
	MW-12	Barium	1,940	1,000
	MW-26	Barium	1,330	1,000
	MW-31	Barium	1,090	1,000
	MW-4	Mercury	60	2.0
	MW-13	Mercury	60	2.0
	MW-19	Mercury	5.8	2.0

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Soluble inorganic concentrations were also compared to secondary drinking water standards. Manganese and iron were frequently found in excess of the recommended secondary standards. Zinc was also found above the secondary standards though less frequently.

#### Organic Contamination

The analytical data demonstrate that groundwater at the Chem-Dyne site is contaminated with a variety of organic compounds, mostly chlorinated volatile organic compounds (VOC's).

To evaluate the organic analytical data, each major fraction of priority pollutant organic compounds was considered. The goals of this evaluation were as follows:

- o Identify the specific compounds or category of compounds that define the contaminant plume.
- o Identify compounds that are exceptionally toxic and/or persistent.
- o Locate the contaminant plume.
- o Identify compounds that constitute most of the plume mass and the general chemical properties of these compounds.

Nonpriority, Tentatively-Identified Compounds. In addition to the priority pollutant organics, the CLP organics data package includes a list of nonpriority compounds that are identified with a computer-correlated library scan. These nonpriority, tentatively-identified compounds were reviewed to determine if any were identified in the perimeter wells at the edge of the monitoring well network.

Except in one sample from MW-21, nonpriority tentatively identified compounds were not found in the perimeter wells. At MW-21, an "unknown" and a "hydrocarbon" were reported at a combined concentration of 50 ug/L.

The numerous nonpriority, tentatively-identified compounds in the onsite and near site samples may be reviewed in more detail in the feasibility study as remedial technologies are screened. For example, some of these compounds may affect the evaluation of treatment alternatives or public health assessments.

Acid Compounds. Two acid fraction priority pollutant organic compounds were identified. Phenol was found at MW-10 in every sample and once at three other onsite wells (MW-26, MW-27, and MW-29). In addition, 2-nitrophenol was identified at MW-10 in the Phase II sample. The maximum

concentration reported for an individual acid compound was 1,000 ug/L (monitoring well MW-10 sampled February 1981). However, individual compound concentrations are generally less than 500 ug/L.

The occurrence of these acid fraction compounds suggests direct groundwater contamination or contaminant degradation byproducts. However, both compounds are biodegradable and nonpersistent; neither compound is especially toxic.

Base/Neutral Compounds (B/N's). Seven B/N compounds were identified in groundwater from each sampling phase. However, the occurrences and concentrations of the compounds were limited. The occurrence of detected base/neutral priority pollutant compounds is summarized in Table 16.

In general, the compounds listed in Table 16 are relatively persistent and not especially toxic except for bis(2-chloroethyl) ether which is a known experimental carcinogen in mice. However, bis(2-chloroethyl) ether was identified in only one sample at MW-15 at 28 ug/L. In addition, it must be noted that several priority pollutants included in the B/N fraction have routine detection limits that are up to 1,000 times greater than published Water Quality Criteria for carcinogenicity protection.

With the exception of MW-15, B/N compounds were quantified in only two other offsite wells. Samples at MW-14 and MW-17 had less than 25 ug/L of phthalates. Therefore, the occurrence of phthalates is not considered further.

Pesticide Compounds. Three pesticide compounds were identified in four of the groundwater samples. In each case, individual concentrations were equal to or less than 0.10 ug/L. The three pesticides and their occurrences are summarized below:

- o     -endosulfan  
      Phase I at MW-12 - 0.08 ug/L  
      (WQC for water ingestion toxicity protection is 74 ug/L)
- o      $\beta$ -BHC  
      Phase I at MW-4 in 0.10 ug/L  
      Phase I at MW-7 in less than 5 ug/L  
      (WQC for carcinogen protection at 1 in 100,000 is 0.163 ug/L)
- o      $\gamma$ -BHC (lindane)  
      Phase III at MW-7 in 0.9 ug/L  
      (WQC for carcinogen protection at 1 in 100,000 is 0.186 ug/L)

Table 16  
SUMMARY OF THE OCCURRENCE OF PRIORITY POLLUTANT  
BASE/NEUTRAL ORGANIC COMPOUNDS IN GROUNDWATER

Dichlorobenzenes (1,2- and 1,4-)

<u>Phase I</u> <u>(April 1983)</u>	<u>Phase II</u> <u>(June-July 1983)</u>	<u>Phase III</u> <u>(October 1983)</u>
MW-10	-	-

Phthalates (bis[2-ethylhexyl] and di-n-octyl)

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-5	MW-6	MW-5
MW-6	MW-9	MW-6
MW-9	MW-14	MW-9
MW-17	MW-28	

Bis(2-chloroethyl) ether

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
-	MW-15	-

Isophorone

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
-	MW-23	MW-23

Naphthalene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
-	-	MW-25 (Trace)
-	MW-26 (Trace)	
-	MW-27 (Trace)	

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These pesticides are considered persistent and relatively toxic. However, their occurrence is infrequent and only at low concentrations. The single occurrence of lindane is noteworthy because its concentration exceeded the Water Quality Criteria for carcinogenicity protection (B-BHC in MW-7 may also have been in excess of WBC but the detection limit for the sample was too high to make a conclusion).

These pesticides are known to have been among the wastes stored at the site and they have been previously identified in contaminated soil and groundwater samples.

Nonpriority Hazardous Substances. Eight nonpriority hazardous substances were identified in various groundwater samples. One of these, acetone, is excluded from consideration because it was used for sampling equipment decontamination and may have affected some samples by decontamination fluid carryover.

The nonpriority hazardous compounds generally range from nonpersistent to somewhat persistent according to 40 CFR 300, Table 5. None of the compounds are unusually toxic. A summary of the compounds identified is presented below:

- |                    |                        |
|--------------------|------------------------|
| o Benzoic acid     | o 4-methyl-2-pentanone |
| o 2-methylphenol   | o 2-butanone           |
| o 4-methylphenol   | o o-xylene             |
| o Carbon disulfide | o Acetone              |

The occurrence of nonpriority hazardous substances was reviewed for the perimeter monitoring wells to check for their presence at the limits of the well network. Two samples, from MW-17 and MW-22, showed butanone and pentanone respectively during Phase I. Both compounds are biodegradable and of low toxicity.

Volatile Compounds. The largest fraction of organic groundwater contamination consists of volatile organic compounds (VOC's). Eighteen priority pollutant VOC's have been identified. VOC's have been found in 25 of the 36 monitoring wells.

Examination of the data indicates that the VOC contamination originates from the site, because, with the exception of one occurrence of tetrachloroethene in upgradient well MW-2 in April 1983, no VOC's have been identified in any of the samples from the upgradient wells. In addition, VOC's were known to have been stored onsite in large quantities.

The priority pollutant VOC's include a variety of chlorinated alkanes and alkenes, benzene, chlorobenzene, ethyl benzene, and toluene. The occurrence of detected volatile priority pollutant organic compounds in monitoring wells and production wells is summarized in Table 17. Refer to Volume 2 of 2 for

Table 17 (Page 1 of 5)  
SUMMARY OF THE OCCURRENCE OF PRIORITY POLLUTANT  
VOLATILE ORGANIC COMPOUNDS IN GROUNDWATER

Benzene

<u>Phase I</u> <u>(April 1983)</u>	<u>Phase II</u> <u>(June-July 1983)</u>	<u>Phase III</u> <u>(October 1983)</u>
MW-3	MW-5	MW-5
MW-4	MW-25	MW-6
MW-5	MW-26	MW-7
MW-6	MW-29	MW-10
MW-7		MW-24
MW-10		MW-25
MW-15		MW-26
MW-18		MW-27
		MW-28
		MW-29

Carbon tetrachloride

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-5	MW-6	MW-6
MW-6	MW-7	MW-7
MW-7	MW-9	MW-9
MW-9	MW-23	MW-23
MW-10		MW-24
MW-13		

Chlorobenzene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-7	MW-5	MW-7
MW-10	MW-25	MW-15
MW-15		MW-25
		MW-29

Table 17 (Page 2 of 5)

1,2-dichloroethanePhase I

MW-5  
MW-6  
MW-10  
MW-13  
MW-15  
MW-18

Phase II

MW-5  
MW-6  
MW-14  
MW-15  
MW-18  
MW-26  
MW-29

Phase III

MW-5  
MW-6  
MW-10  
MW-13  
MW-15  
MW-29  
MW-30  
MW-33

1,1,1-trichloroethanePhase I

MW-5  
MW-6  
MW-7  
MW-10  
MW-13  
MW-15

Phase II

MW-5  
MW-6  
MW-7  
MW-10  
MW-29

Phase III

MW-5  
MW-6  
MW-7  
MW-10  
MW-13  
Vaughn well  
Champion No.4

1,1-dichloroethanePhase I

MW-4  
MW-5  
MW-7  
MW-10  
MW-15  
MW-18

Phase II

MW-5  
MW-23

Phase III

MW-4  
MW-5  
MW-15  
MW-30  
MW-33  
MW-34

1,1,2-trichloroethanePhase I

MW-5  
MW-6  
MW-10  
MW-12  
MW-13  
MW-15  
MW-18

Phase II

MW-5  
MW-6  
MW-10  
MW-13  
MW-15  
MW-18  
MW-29

Phase III

MW-5  
MW-6  
MW-10  
MW-13  
MW-15  
MW-18  
MW-24  
MW-29

Table 17 (Page 3 of 5)

1,1,2,2-tetrachloroethane

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-5	MW-5	MW-5
MW-7	MW-10	MW-6
MW-10	MW-13	MW-10
MW-13	MW-15	MW-13
MW-15		MW-15
MW-18		

Chloroethane

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-4		MW-4
MW-15		

Chloroform

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-5	MW-5	MW-5
MW-6	MW-6	MW-6
MW-7	MW-7	MW-7
MW-9	MW-9	MW-9
MW-10	MW-10	MW-10
MW-13	MW-23	MW-13
MW-15	MW-24	MW-15
MW-18	MW-29	MW-23
		MW-24
		MW-29

1,1-dichloroethene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-5	MW-5	MW-5
MW-7	MW-15	MW-13
MW-10	MW-26	MW-15
MW-12	MW-29	MW-18
MW-13		MW-26
MW-15		MW-29
MW-18		MW-30
		MW-33
		MW-34

Table 17 (Page 4 of 5)

Trans-dichloroethene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-4	MW-4	MW-4
MW-5	MW-5	MW-5
MW-10	MW-6	MW-6
MW-12	MW-10	MW-10
MW-13	MW-12	MW-13
MW-15	MW-13	MW-15
MW-18	MW-15	MW-18
	MW-18	MW-23
	MW-23	MW-24
	MW-26	MW-26
	MW-28	MW-27
	MW-29	MW-28
		MW-29
		MW-30
		MW-33
		MW-34
		Champion No.1
		Champion No.4

1,2-dichloropropane

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-7	-	-
MW-10		
MW-15		
MW-18		

Ethylbenzene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-10	MW-25	MW-25
MW-15	MW-26	MW-26
		MW-27
		MW-28

Tetrachloroethene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-2	MW-5	MW-5
MW-5	MW-10	MW-6
MW-10	MW-13	MW-10
MW-12	MW-15	MW-13
MW-13	MW-23	MW-15
MW-15	MW-24	MW-24
	MW-29	MW-29

the case and in addition the City Electric Plant wells operated at a uniform rate without cycling ON and OFF. Methods were then attempted to determine the distance and direction of an unknown pumping well and then the rate at which the well was pumping. The distance and direction to the unknown well (or wells) was determined by applying the Law of Times as described in Ferris et al., (1962). Because of the variability of the time of data measurements there were many assumptions and a considerable amount of uncertainty in the calculations. In general, the results indicated an unknown pumping well in a southwesterly direction from the site approximately 1,000 to 3,000 feet away. Similar methods were also used to estimate a pumping rate for the unknown wells. Again, this range was fairly wide but indicated an average value of 2000 gpm.

The Champion wells are located within the appropriate distance from the site in a west to southwest direction. The plant engineering was contacted and stated that water pumping at the plant during the test period had been between 2.03 and 2.13 million gallons per day. Although it was not possible to get the hourly operating records for the Champion wells they are considered a likely source for the fluctuations in the monitoring wells during the test. This is also substantiated by the change in water levels recorded in wells MW-19 and MW-32 during the time Champion was testing their well No. 2 on October 26, 1983.

However, the possibility that other wells such as the Beckert Paper wells or Mercy Hospital wells are responsible or contributors to the observed fluctuations is not ruled out.

Aquifer Parameters. The important parameters to be determined by the aquifer pump test were the transmissivity of the aquifer and the storage coefficient. In addition it was desirable to estimate the directional variation or anisotropy of the aquifer transmissivity if possible.

Water level measurements during the test were collected by pressure transducers, electrical measuring tapes and by Stevens Recorders. The specific method of measurement for each well is included in Table 3 of the aquifer test data volume. The wells nearest the test well and the wells having pressure transducers and recorders produced the most complete record of water level changes during the test. As discussed previously, the impact of wells and perhaps other outside influences created a level of background noise against which the

analysis of the pump test data was conducted. This background noise and the aquifer heterogeneity resulted in a relatively broad range of values for the aquifer properties. A summary of the derived aquifer parameters are included in Table 14.

Drawdown data were analyzed using Theis type curve methods and Jacob straight line methods. Where possible several methods of analysis were applied to each well. Drawdown data having a considerable amount of noise were difficult to analyze and the results obtained should be regarded as estimates of the aquifer properties only. Furthermore, Jacob Straight Line methods were applied to data from wells that do not meet the criteria for the Jacob method to be strictly valid, i.e., when the value of  $u$  in the equation:

$$u = \frac{1.87 r^2 S}{Tt} \text{ is greater than } 0.01$$

It is recognized that data analyzed in this manner provide only an estimation of aquifer properties. Aquifer properties determined by this method are noted with an asterisk in Table 14.

Detailed information about the aquifer pump test and methods of analysis are presented in the TM for Subtask 3-3.5 of Volume 2 of 2.

Transmissivity. Results of the aquifer pump test yielded aquifer transmissivities of  $3 \times 10^4$  gal/day/ft to  $7 \times 10^5$  gal/day/ft. This observed range in aquifer transmissivity is in general agreement with previous tests in the area and consistent with the variability or heterogeneity of the aquifer. Most of the calculated  $T$  values fall within a smaller range of  $1 \times 10^5$  to  $3 \times 10^5$  gal/day/ft.

The higher transmissivities computed from observation wells MW-20, MW-33, and MW-35 suggest aquifer heterogeneity with respect to transmissivity. The transmissivity increases to the west as the aquifer increases in thickness. There is also an indication that there is a preferred direction of permeability toward the west based on chemical transport data.

Storage Coefficient. Values of the storage coefficient in the aquifer ranged from approximately 0.0005 to 0.3. The aquifer responded in some areas as an unconfined aquifer with large storage coefficients and in other areas as a semiconfined system with very small storage coefficients. These responses are consistent with the erratic presence (or

Well Number	Depth (ft)	Distance From Test well (ft)	PERMEABILITY (gpd/ft)				STORAGE COEFFICIENT				
			Method of Analysis		Method of Analysis		Method of Analysis		Method of Analysis		
			Unconfined Vertical Movement	Delayed Yield Early	Delayed Yield Late	Jacob Drawdown	Jacob Recovery	Unconfined Vertical Movement	Delayed Yield Early	Delayed Yield Late	Jacob Drawdown
Test Well	80					$1.64 \times 10^5$					.10
MW-1	62	957				$6.25 \times 10^5$ *					
MW-2	36	965				$7.1 \times 10^5$ *					
MW-3	35	848	No Drawdown Curve Evident								
MW-4	32	537				$4.4 \times 10^5$ *					
MW-5	34	313	$1.7 \times 10^5$		$1.85 \times 10^5$	$3.65 \times 10^5$ *		.073		.07	
MW-6	31	420	$3.6 \times 10^5$		$1.55 \times 10^5$	$3.9 \times 10^5$ *		.052		.10	
MW-7	34	480				$5.3 \times 10^5$ *					
MW-8	40	740				$4.8 \times 10^5$ *					
MW-9	33	487	$1.94 \times 10^5$		$2.3 \times 10^5$	$3.5 \times 10^5$ *		.081		.082	
MW-10	35	186	$.36 \times 10^5$	$3.8 \times 10^5$	$.29 \times 10^5$	$.96 \times 10^5$ *		.30	.11	.27	
MW-11	40	502				$1.95 \times 10^5$ *					
MW-12	58	232				$1.38 \times 10^5$ *					
MW-13	32	232	$1.03 \times 10^5$		$1.04 \times 10^5$	$2.1 \times 10^5$ *		.32		.33	
MW-14	31	701	No Data Collected During Test, Well Dry								
MW-15	40	611	No Drawdown Curve Evident								
MW-16	41	1,275				$4.0 \times 10^5$ *					
MW-17	44	1,518				$2.8 \times 10^5$ *					
MW-18	38	692				$7.16 \times 10^5$ *					
MW-19	65	1,204	No Drawdown Curve Evident								
MW-20	40	1,225	No Drawdown Curve Evident								
MW-21	48	1,259	No Drawdown Curve Evident								
MW-22	78	1,261	No Drawdown Curve Evident								
MW-23	35	298	$1.2 \times 10^5$		$1.1 \times 10^5$	$2.1 \times 10^5$ *		.20		.19	
MW-24	35	398				$1.88 \times 10^5$ *					
MW-25	35	53	$1.2 \times 10^5$	$1.1 \times 10^5$	$1.4 \times 10^5$	$1.2 \times 10^5$ *	$.7 \times 10^5$	.071	.008	.074	.076
MW-26	65	62	$1.9 \times 10^5$	$2.9 \times 10^5$	$1.6 \times 10^5$	$2.7 \times 10^5$ *	$2.6 \times 10^5$	.15	.001	.24	.02
MW-27	35	272	$.85 \times 10^5$		$.57 \times 10^5$	$1.14 \times 10^5$ *		.074		.098	
MW-28	65	248	$3.9 \times 10^5$	$3.8 \times 10^5$		$1.75 \times 10^5$ *		.0076	.0009		
MW-29	35	167	$1.6 \times 10^5$		$1.6 \times 10^5$	$1.6 \times 10^5$ *		.12		.11	
MW-30	40	993				$.88 \times 10^5$ *					
MW-31	40	465				$3.5 \times 10^5$ *					

CLT464/11-1

Table 16 (Continued)

Well Number	Depth (ft)	Distance From Test well (ft)	TRANSMISSIVITY (mpd/ft)				STORAGE COEFFICIENT				
			Method of Analysis		Method of Analysis		Method of Analysis		Method of Analysis		
			Unconfined Vertical Movement	Delayed Yield Early	Delayed Yield Late	Jacob Drawdown	Jacob Recovery	Unconfined Vertical Movement	Delayed Yield Early	Delayed Yield Late	Jacob Drawdown
MW-32	95	1,236	No Drawdown Curve Evident								
MW-33	65	690'	$7.7 \times 10^{-5}$	$6.4 \times 10^{-5}$	$3.9 \times 10^{-5}$	$4.2 \times 10^{-5a}$	$5.9 \times 10^{-5a}$	.073	.0008	.045	
MW-34	40	454				$4.2 \times 10^{-5a}$	$4.2 \times 10^{-5a}$				
MW-35	66	651	$6.9 \times 10^{-5}$	$6.0 \times 10^{-5}$	$6.0 \times 10^{-5}$	$6.3 \times 10^{-5a}$		.0045	.002	.0048	
MW-36	40	696				$4.38 \times 10^{-5a}$					

## Distance Drawdown Methods

Using Shallow Wells to the East (MW-2, 4, 5, 29, 25)	$T = 3.1 \times 10^{-5a}$
Using Shallow Wells to the West (MW-13, 18, 20)	$T = 4.8 \times 10^{-5a}$
Using Shallow Wells to the North (MW-25, 27, 11)	$T = 1.4 \times 10^{-5a}$
Using Shallow Wells to the South (MW-16, 8, 10, 11)	$T = 1.3 \times 10^{-5a}$
Using Deep Wells to the West (MW-26, 17, 33)	$T = 2.9 \times 10^{-5a}$
Using Deep Wells to the North (MW-26, 16)	$T = 1.8 \times 10^{-5a}$

## NOTES:

<sup>a</sup> Method of calculating T is not strictly valid,  $\alpha$  greater than .01; therefore, value of T is only an approximation.

<sup>a</sup> See S.W. Lohman, "Groundwater Hydraulics," U.S. Geologic Survey Professional Paper 708.

absence) of silt/clay lenses throughout the site and particularly in the west where a more continuous clay layer is reported to exist.

Hydraulic Conductivity. The aquifer thickness at the test well location is approximately 180 feet. It increases westward toward the river and decreases eastward as the bedrock rises. Using 180 feet as an average thickness, the horizontal hydraulic conductivity ranges from 200 to 3,800 gal/day/ft<sup>2</sup> with an average of 1,100 gal/day/ft<sup>2</sup>.

The results of the pumping test data analysis indicate that the vertical hydraulic conductivity is less than or equal to the horizontal hydraulic conductivity throughout the aquifer. The vertical hydraulic conductivity ranges from approximately  $0.6 \times 10^3$  to  $1.1 \times 10^3$  gal/day/ft<sup>2</sup>. It appears that this relatively large range is a result of the variable nature of the aquifer material.

Groundwater Flow Directions and Velocity of Movement.

Evaluating the data from the aquifer pump test, groundwater level measurements, water quality data and soil boring data allows some general conclusions and interpretations to be drawn on groundwater flow direction. It is important to note that both vertical and horizontal flow components are necessary to describe the groundwater flow. Contours on the water table surface for shallow wells are shown in Figures 14, 15, and 16.

From a regional perspective groundwater flow in the alluvial deposits in the Great Miami River basin is parallel to the flow in the river. On a site-specific basis the directions of flow are influenced by hydraulic structures such as dams and canals, streams and heavy withdrawals of groundwater by municipal or industrial wells. All of these factors have some effect on the groundwater system around the Chem-Dyne site.

The Ford Canal borders the Chem-Dyne site on the northeast and north. A dam and hydroelectric plant are located at the north end of the Ford Building. The level of water behind the dam is approximately 25 feet higher than downstream from the dam. This higher level of water behind the dam may induce stream flow to infiltrate into the aquifer and artificially maintain high groundwater levels. Well No. MW-3 and to some extent well Nos. MW-1 and MW-2 may be influenced by this recharge from the Ford Canal. Existing water level records taken during the FIT investigation and the RI investigation have consistently recorded high water levels in the northeast area near the Ford Canal and well Nos. MW-1, MW-2, and MW-3.

# PIEZOMETRIC MAP OF CHEM-DYNE

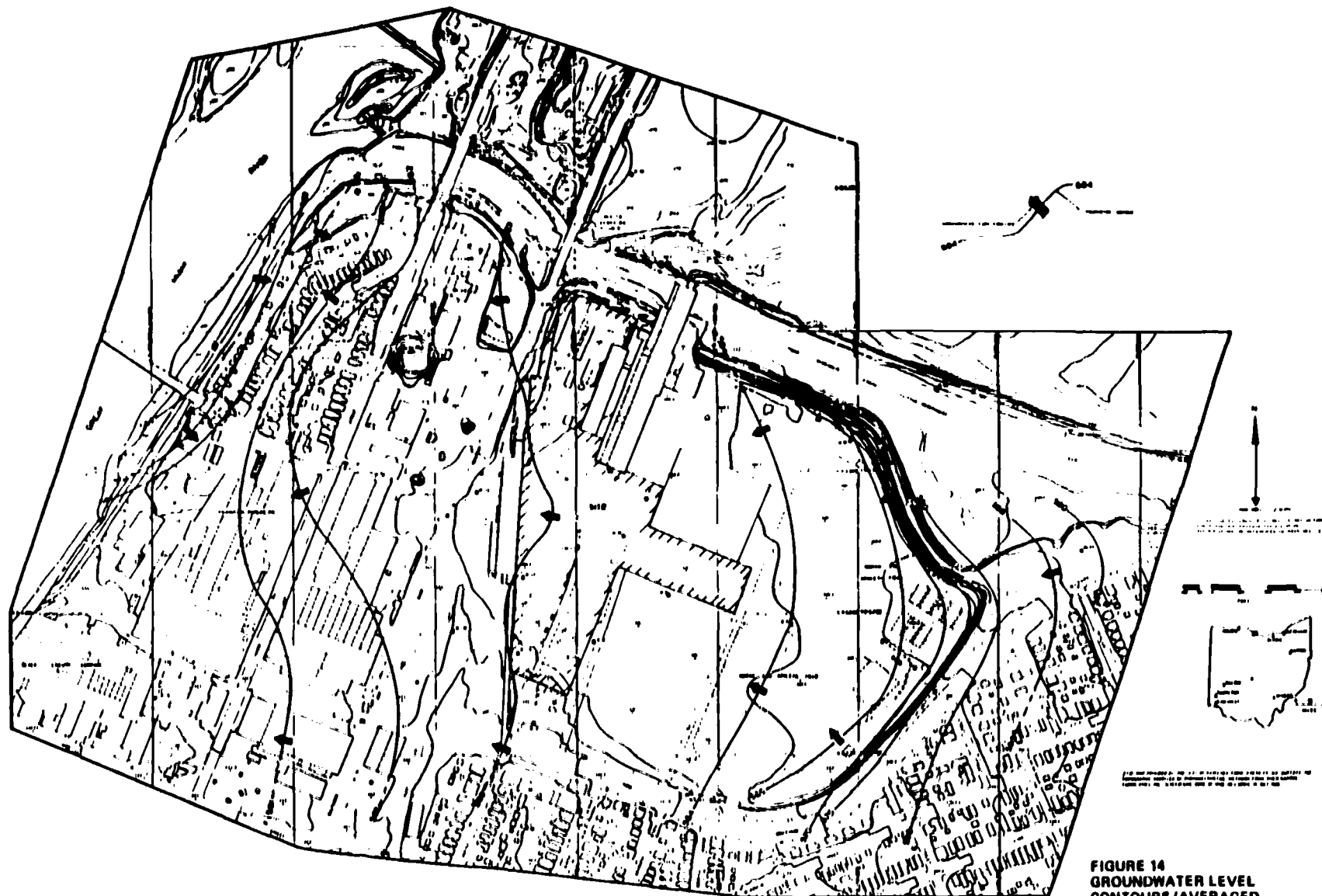
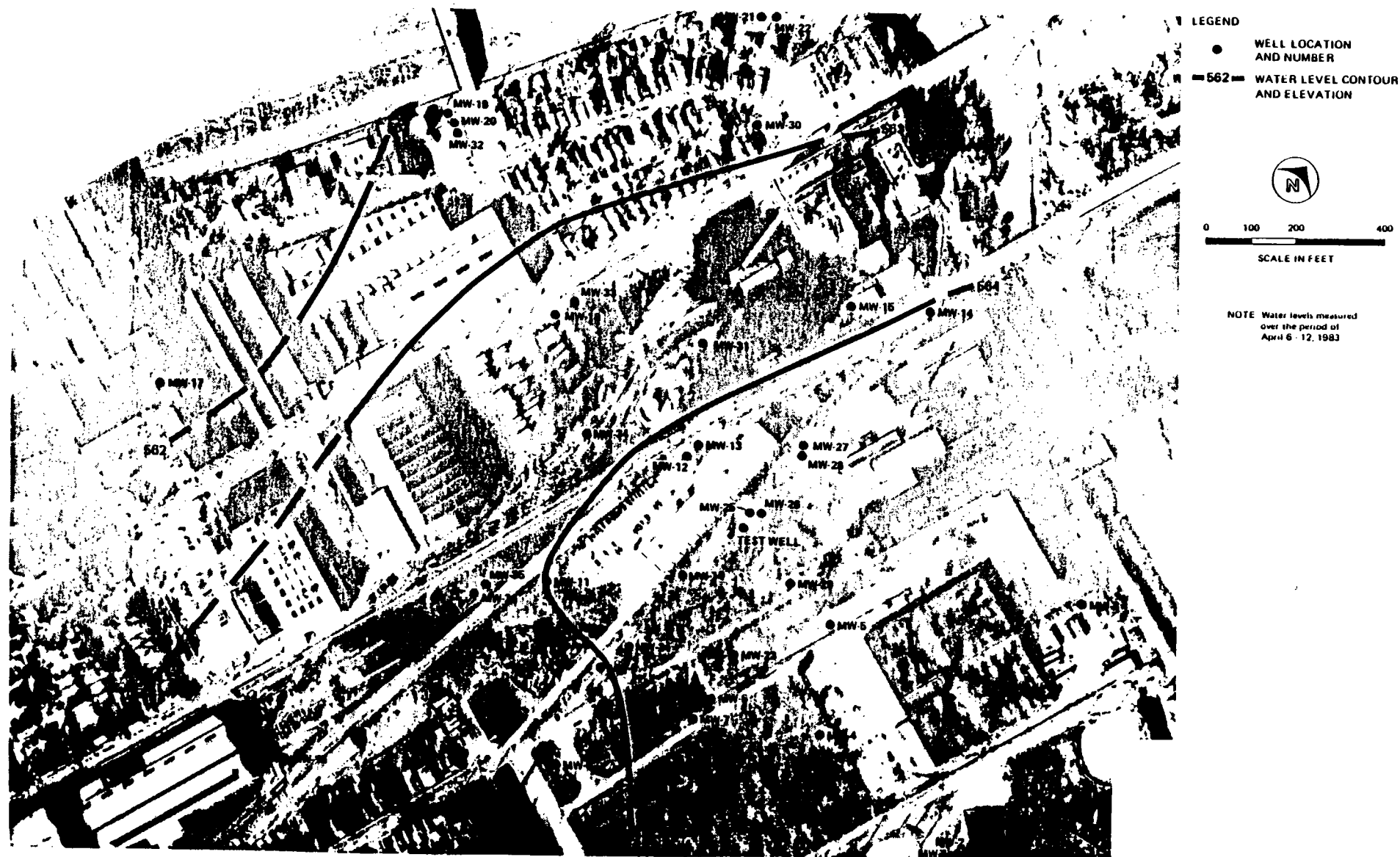
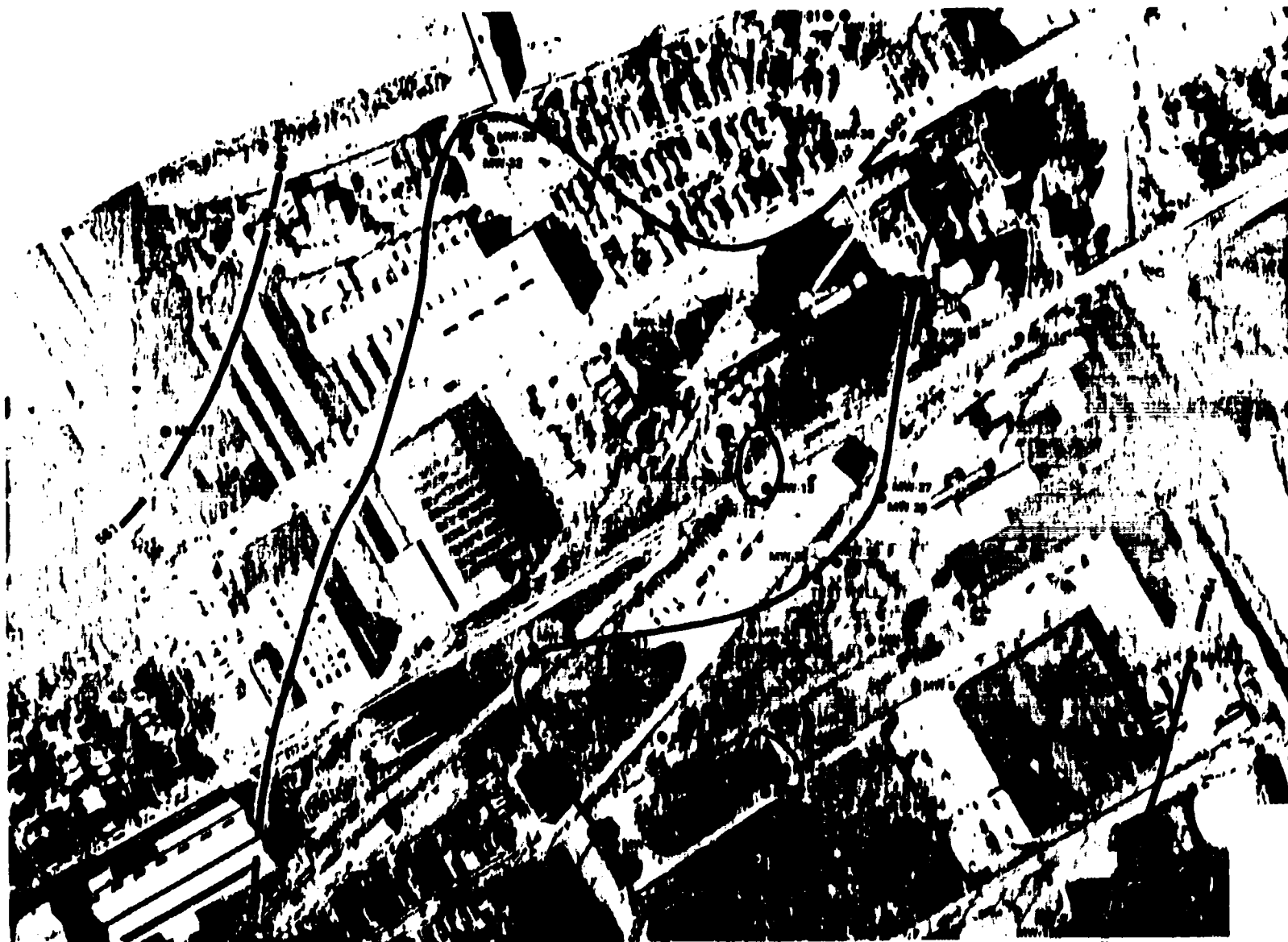


FIG. 14 WAS PREPARED BY THE U.S. ENVIRONMENTAL PROTECTION AGENCY AS PART OF THE INVESTIGATION OF THE CHEM-DYNE CASE. IT IS NOT TO BE USED FOR ANY OTHER PURPOSE.

**FIGURE 14**  
**GROUNDWATER LEVEL**  
**CONTOURS (AVERAGED**  
**OVER DURATION OF FIT INVESTIGATION)**  
**CHEM-DYNE RI**



**FIGURE 15**  
**GROUNDWATER**  
**LEVEL CONTOURS**  
**APRIL 1983**  
 CHEM - DYNE RI



LEGEND  
● WELL LOCATION  
AND NUMBER II  
=552= WATER LEVEL CONTOUR  
AND ELEVATION



0 100 200 400  
SCALE IN FEET

NOTE. Water levels measured  
over the period of  
October 27 - 28, 1983

FIGURE 16  
GROUNDWATER  
LEVEL CONTOURS  
OCTOBER 1983  
CHEM-DYNE RI

From this high area horizontal components of groundwater flow are generally westerly to southwesterly until in the vicinity of Third Street. In the area between the Great Miami River and Third Street interpretation of groundwater levels from the data available allow essentially two different flow regimes to be proposed. The first flow regime is very similar to the contour pattern drawn by the FIT investigation (Figure 14). The second interpretation is that shown by Figure 16 that corresponds to water levels measured in October during the RI investigation. Both of these interpretations may be equally valid when only the horizontal components of flow are considered.

The interaction of the river and the groundwater are uncertain at this time because river stage data at the site are not available. The groundwater contours plotted by the FIT team indicated water flowing from the river into the groundwater system. During late October the river was at a low stage and would be expected to be receiving water from the shallow groundwater. The groundwater/river interactions are complex and change over time. The presence of downward vertical gradients dictates that when flow is moving from the river it is moving around or through the silt and clay unit and into the deeper zones of the aquifer from which the Champion wells derive their water. These vertical gradients are present even when groundwater flow is into the river, indicating only the shallow, near surface groundwater is contributing to the river in this area. The river apparently is a recharge boundary in the shallow system during higher river stages and a discharge boundary during low river stages. The deeper groundwater system, below the silt and clay unit, is more strongly influenced by the regional flow and strong vertical gradients presumed caused by the Champion Paper Company wells.

The directional variation in aquifer hydraulic conductivity or aquifer anisotropy and the vertical components of flow must be considered if a more complete understanding of flow directions is to be acquired. Although not definitive, the aquifer pump test data indicated that there may be a higher value of transmissivity parallel to the river than perpendicular to the river.

Vertical gradients will also strongly affect the flow direction. There are 8 well nest sites among the 36 monitoring wells that allow vertical gradients to be determined. These well nests show an increasing downward vertical gradient in an east to west direction ranging from near zero at well Nos. MW-1 and MW-2 to as high as 0.05 ft/ft at well Nos. MW-19, MW-20, and MW-32. Horizontal gradients normally range from 0.001 ft/ft to 0.003 ft/ft.

The impact of the strong downward vertical gradients on the direction of groundwater flow is difficult to quantify without numerical modeling techniques. However, reasonable interpretations can be made. Under the FIT interpretation of groundwater contours, flow from east of Third Street would be combined with infiltration from the river and would generally flow in a southerly direction parallel to the river. The contoured data from October would remain unchanged but flow again would be diverted more toward the southwest parallel to the river.

When the strong vertical gradients are considered in conjunction with the soil boring data and the data from the pump test an alternate interpretation of groundwater flow is possible. The affect of the strong vertical gradients is to indicate a downward flow of groundwater at a rate approaching the same velocity as horizontal groundwater flow if permeabilities are as calculated. Because of low vertical gradients in the eastern portions of the area, the rate of vertical movement is nearly insignificant but as vertical gradients increase in a westerly direction along a line from well Nos. MW-1, MW-2, to MW-19 and MW-20 the rate of vertical movement increases dramatically. The presence of the clay layer near the rivers eastern edge and continuing westward would suggest that groundwater flow is moving downward, beneath this clay layer and either flowing under the Great Miami River or slightly under and parallel to the river.

With the limited data points in the west and southwest areas it is not possible to determine unequivocally whether flow is moving under the river or parallel to the river. It is reasonable to assume that both situations are occurring to some extent. The Champion wells immediately across the river exert a strong influence on the deep groundwater flow below the clay layer. The U.S. EPA technical memorandum on modeling of groundwater flow and contamination transport illustrated that the Chem-Dyne site maybe within the capture zone or the chamption wells. The regional trend of groundwater flow is parallel to the river. These factors both contribute to influencing the directions of groundwater flow.

Some conclusions and observations can be made with the available data:

- o The results of the aquifer pump test provided a range of values for transmissivity and storage coefficients, from  $0.3 \times 10^5$  gpd/ft to  $7 \times 10^5$  gpd/ft for transmissivity and 0.0009 to 0.32 for storage coefficients. Most of the values for transmissivity fall within a much narrower range

Table 17 (Page 5 of 5)

Toluene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-4	MW-5	MW-10
MW-5	MW-25	MW-15
MW-7		MW-25
MW-10		MW-26
MW-11		
MW-12		
MW-13		
MW-15		
MW-17		
MW-20		
MW-21		

Trichloroethene

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-4	MW-5	MW-4
MW-5	MW-10	MW-5
MW-10	MW-12	MW-6
MW-12	MW-13	MW-10
MW-15	MW-15	MW-13
	MW-23	MW-15
	MW-29	MW-18
		MW-23
		MW-24
		MW-26
		MW-29
		MW-30
		Champion No.1

Vinyl Chloride

<u>Phase I</u>	<u>Phase II</u>	<u>Phase III</u>
MW-4	MW-5	MW-5
MW-10	MW-12	MW-10
MW-12	MW-15	MW-15
MW-15	MW-18	MW-18
MW-18	MW-26	MW-26
Vaughn well	Vaughn well	MW-28
		MW-30
		MW-33
		MW-34
		MW-36
		Vaughn well

Methylene Chloride

Excluded from tabulation because methylene chloride is a known laboratory and sample container artifact.

GLT442/16

GLT442/16

detailed tabulation of VOC concentrations. Selected chemical properties of these compounds are summarized in Table 18.

To describe the overall distribution of VOC's in the near-surface groundwater, the total concentration of all VOC's (excluding methylene chloride, which is a potential decontamination and/or laboratory artifact) was calculated for each well and each sampling phase. These total VOC concentrations are shown on Figures 22 and 23 for FIT and Roy F. Weston data and with approximate concentration contours for shallow wells in Figures 24, 25, and 26 for Phase I, II and III respectively. Two observations can be noted from these sketches: first, VOC contamination has spread beyond the site limits especially toward the west; second, there are two separate areas of peak VOC concentrations.

The two areas of peak VOC concentrations are in the vicinity of MW-10 and in the vicinity of MW-15. A sample from shallow onsite monitoring well MW-27 installed during Phase II suggests that VOC contamination in the uppermost portion of the aquifer may not have been continuous between wells MW-10 and MW-15 in June-July 1983.

Examination of the major constituents in these high concentration areas reveals that the following six VOC's are each found in concentrations greater than 10,000 ug/L at least once in samples from these areas:

- |                         |                         |
|-------------------------|-------------------------|
| o Chloroform            | o Trichloroethene (TCE) |
| o 1,1-dichloroethane    | o Trans-dichloroethene  |
| o 1,1,2-trichloroethane | o Vinyl chloride        |

Comparison of the VOC constituents at the peak concentration areas show somewhat different mixtures. Contamination at MW-15 included most of the same compounds as the MW-10 area but it consistently had much higher concentrations of 1,2-dichloroethane and 1,1,2-trichloroethane, which were in relatively low concentration at MW-10 and absent from onsite wells MW-6, MW-23, and MW-34.

To describe the distribution of specific VOC's in the near-surface groundwater, data from Phase III analysis are shown in Figures 27 through 36 for each VOC identified (absence of a concentration value on these figures indicates compound not detected or present at concentrations below detection limit). Except for benzene, chloroform, and 1,1,2,2-tetrachloroethane each of these figures shows two separate areas of high concentrations. These figures also illustrate the following observations on VOC contamination:

- o The most widespread VOC is trans-dichloroethene.

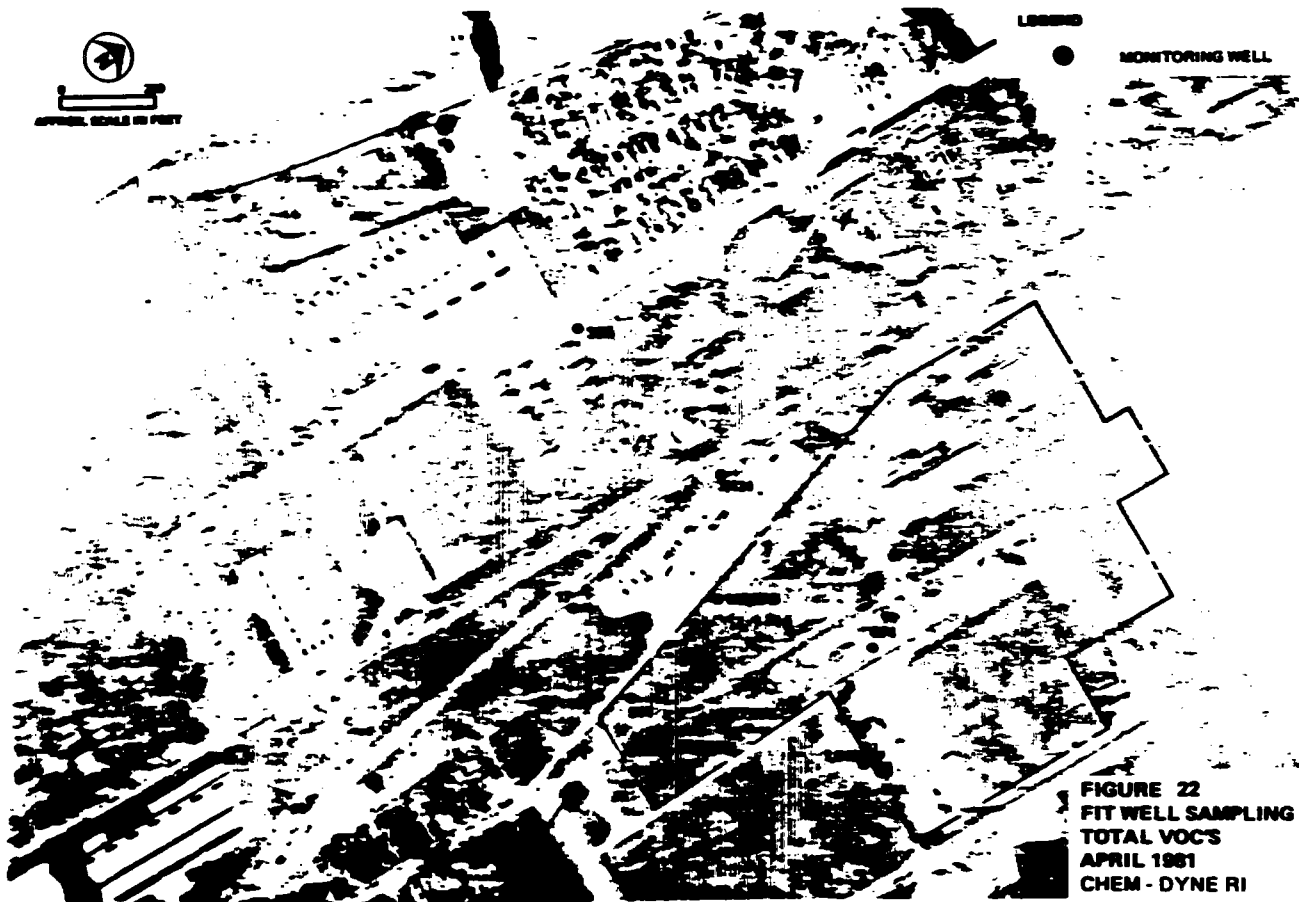
Table 18  
SUMMARY OF SELECTED CHEMICAL PROPERTIES  
OF PRIORITY POLLUTANT VOC'S

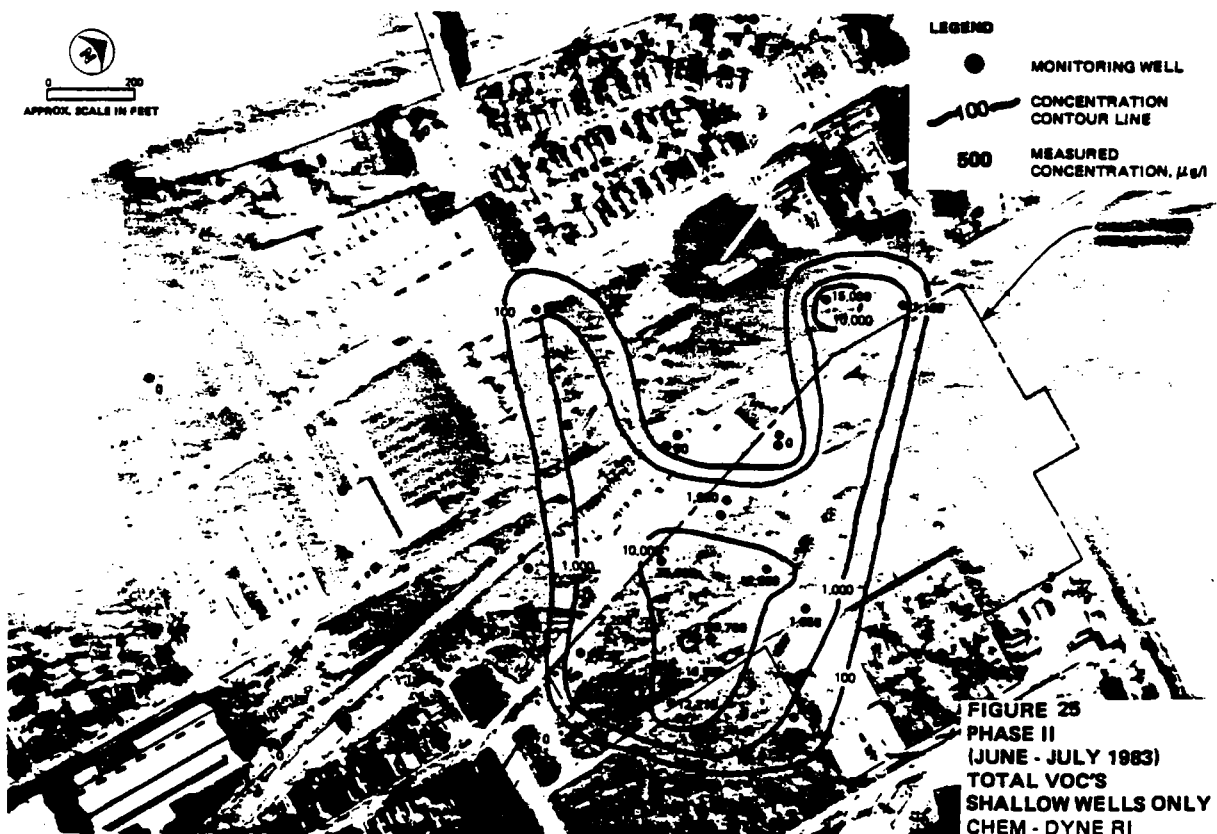
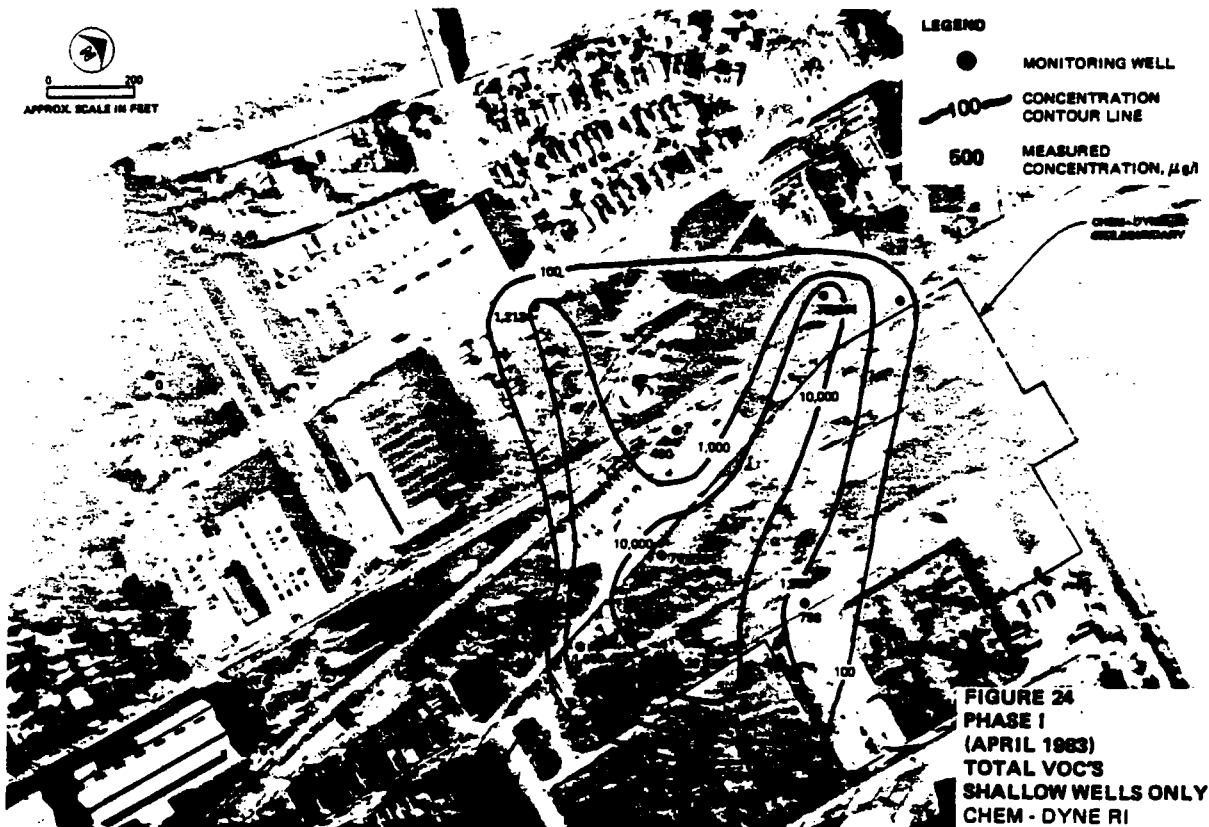
<u>Volatile Priority Pollutant Compound</u>	<u>Density @ 20°C (g/ml)</u>	<u>Solubility in H<sub>2</sub>O @ 20°C (mg/L)</u>	<u>Henry's Law Constant, H<sub>3</sub> m<sup>3</sup> atm/molx10<sup>-3</sup></u>	<u>Log Octanol/Water, Partition Coefficient, K<sub>ow</sub></u>	<u>Molecular Weight</u>
benzene	0.8787	1,800	5.55	N/A	78.12
carbon tetrachloride	1.5940	800	30.2	2.64	153.8
chlorobenzene	1.107	472	3.93	2.84	112.6
1,2-dichloroethane	1.2351	8,300	1.10	1.48	98.98
1,1,1-trichloroethane	1.3390	950	4.92	2.17	133.4
1,1-dichloroethane	1.1757	5,500	5.45	1.79	98.96
1,1,2-trichloroethane	1.4397	4,500	N/A	2.17	133.4
1,1,2,2-tetrachloroethane	1.5406	2,900	N/A	2.56	167.8
chloroethane	0.8978	5,740	N/A	1.54	64.52
chloroform	1.4832	9,600	3.39	1.97	119.4
1,1-dichloroethene	1.218	5,000	15.0	1.48	96.94
trans-dichloroethene	1.2565	6,300	5.32	1.48	96.94
1,2-dichloropropane	1.1560	2,700	2.82	2.28	113.0
ethylbenzene	0.8670	206	6.44	3.15	106.2
methylene chloride	1.3266	16,700	3.19	1.25	89.94
tetrachloroethene	1.6227	150	28.7	2.88	165.8
toluene	0.866	535	5.93	2.69	92.13
trichloroethene	1.4642	1,000	11.7	2.29	131.4
vinyl chloride	0.9106	2,800 <sup>a</sup>	N/A	0.60	62.5

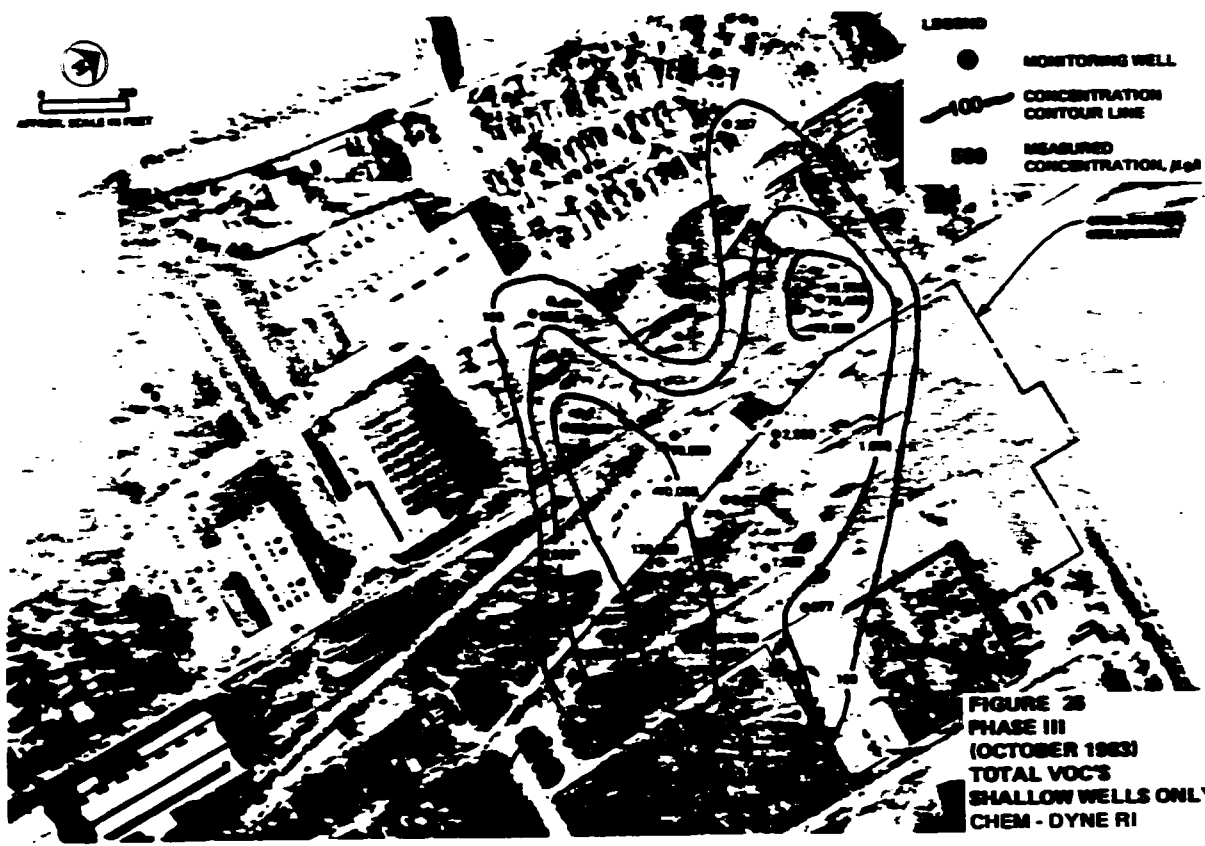
N/A = Not available

<sup>a</sup>Source: Saxina, Hazard Assessment of Chemicals, Vol. 2, 1983, p 254. Solubility in water at 25°C.

NOTE: Values from EPA-600/8-80-042a Treatability Manual: Volume I. Treatability Data.

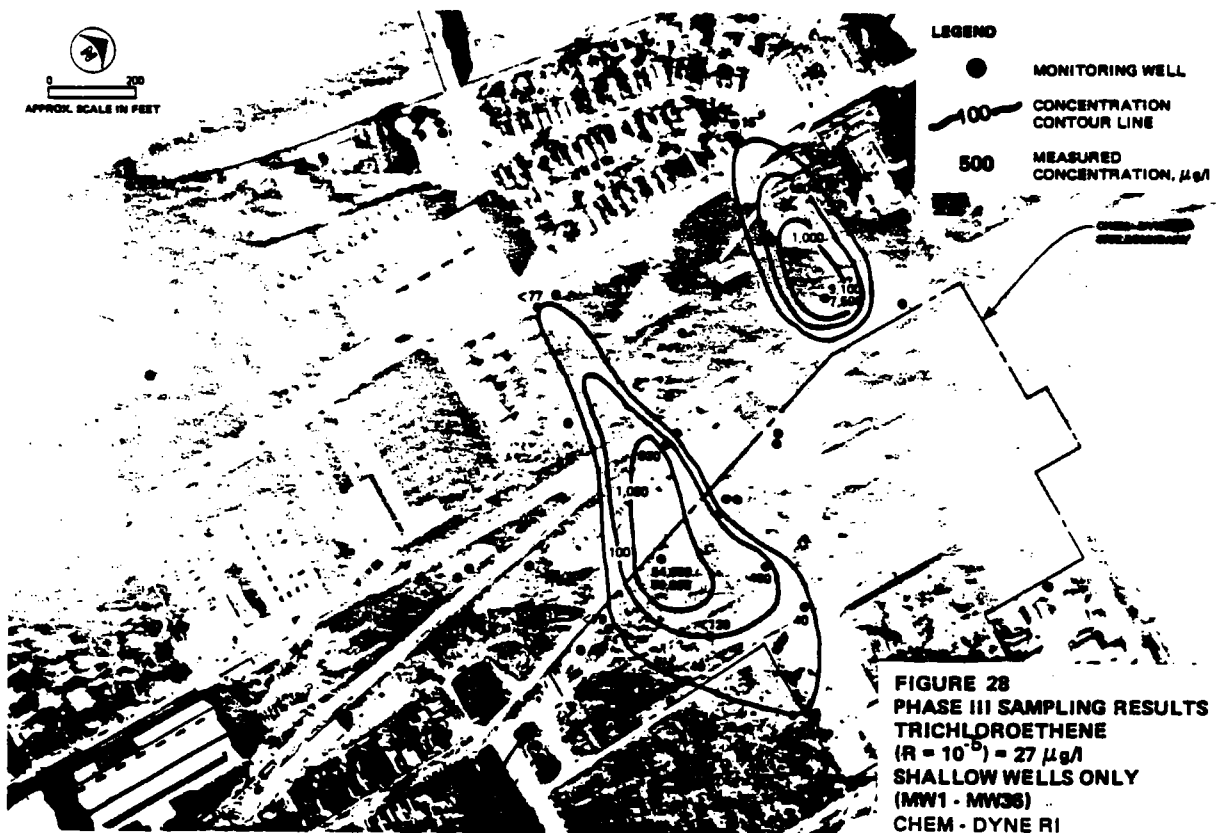
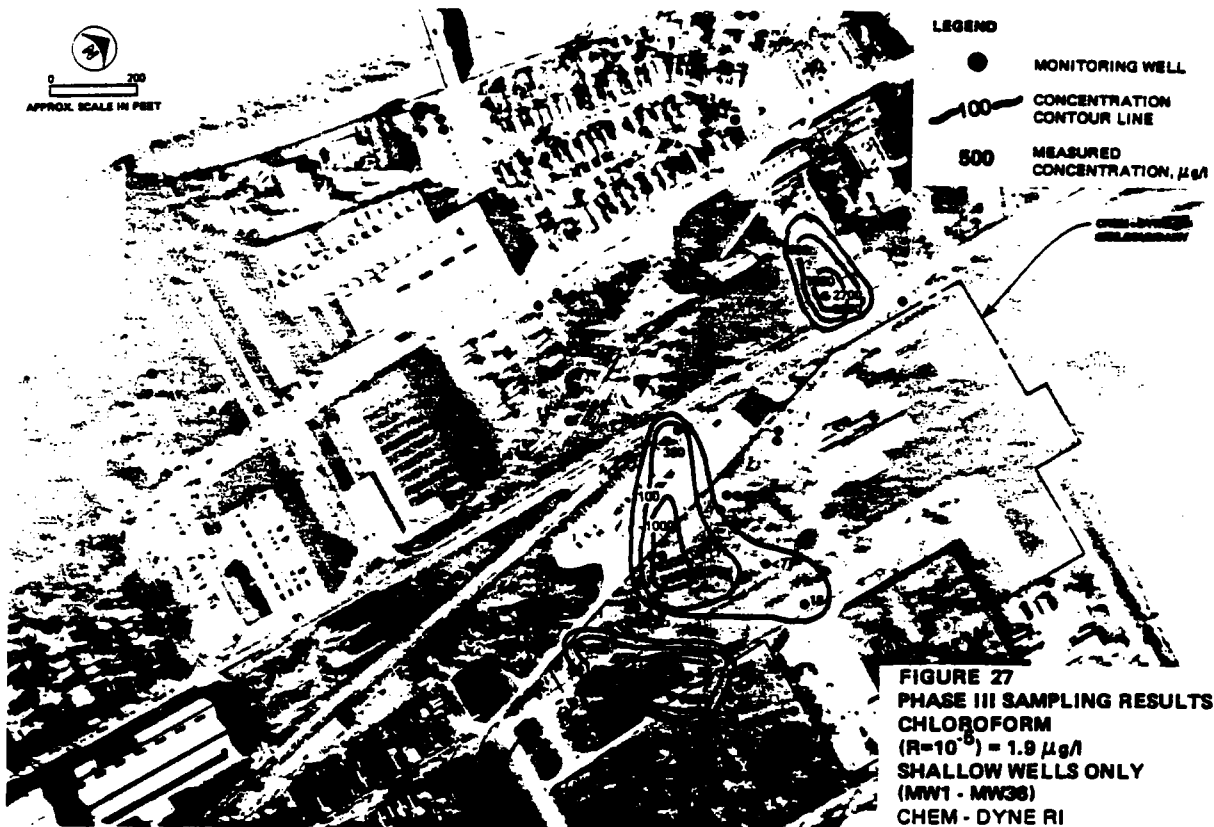


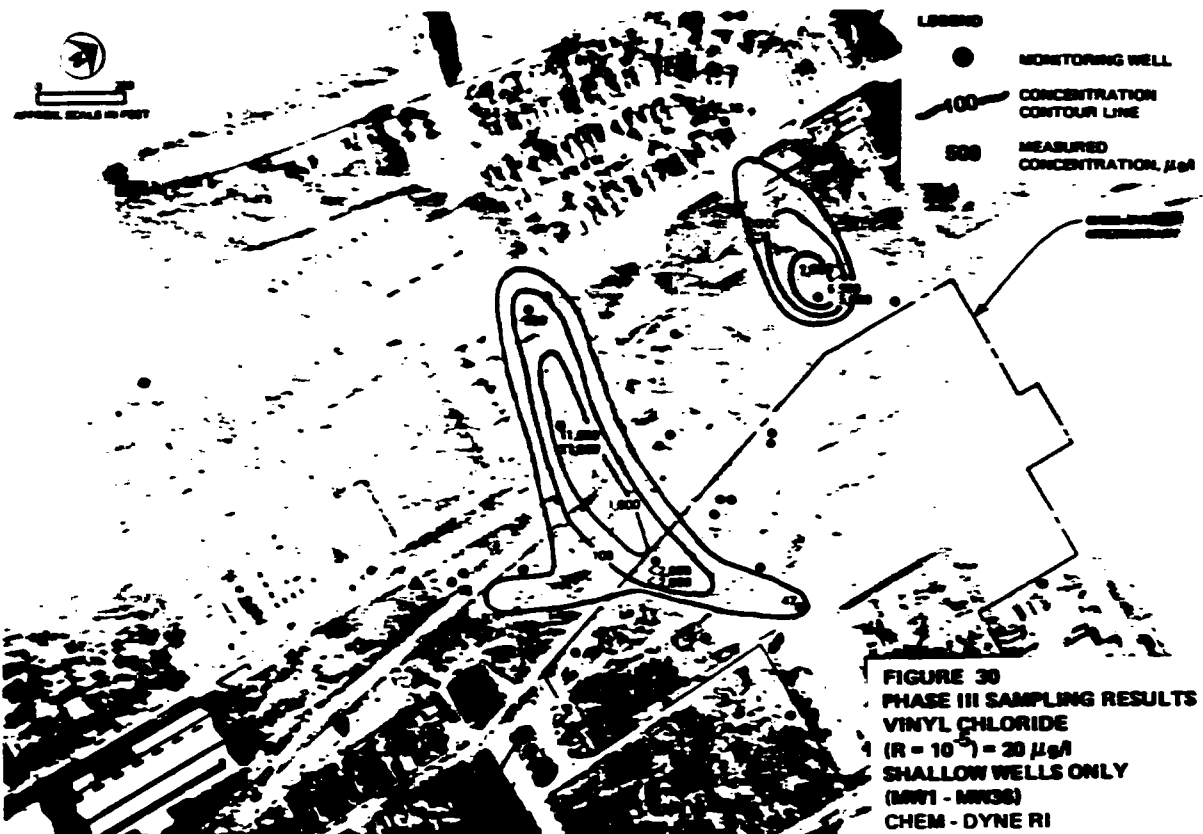


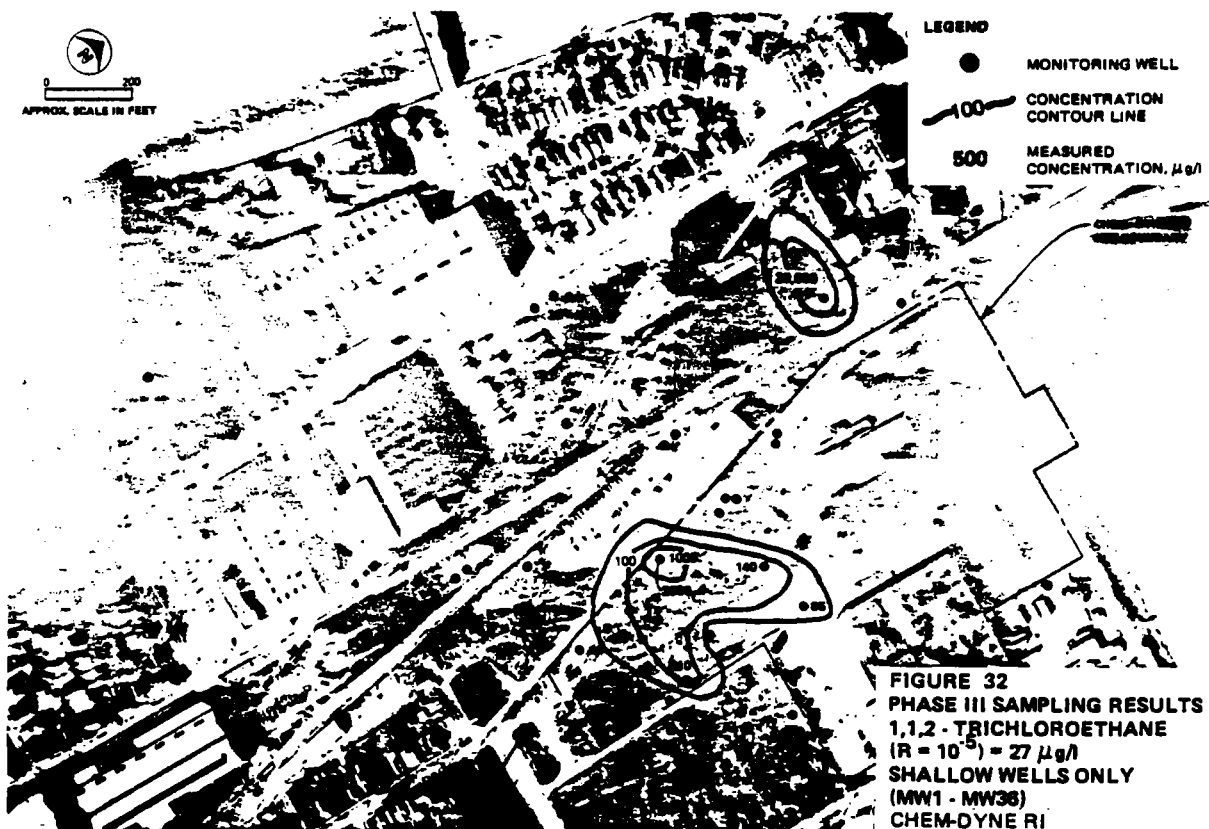
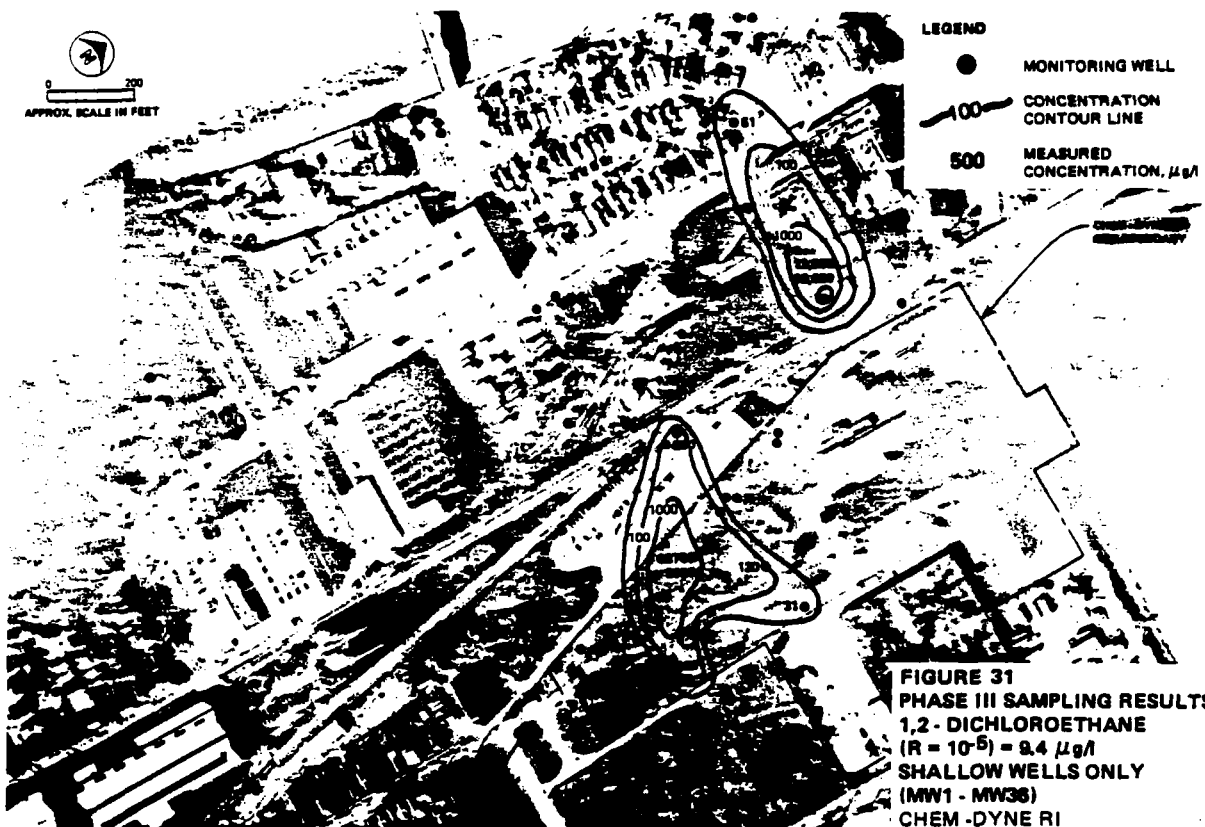


- LEGEND
- MONITORING WELL
  - CONCENTRATION CONTOUR LINE
  - 500 MEASURED CONCENTRATION,  $\mu\text{g/L}$

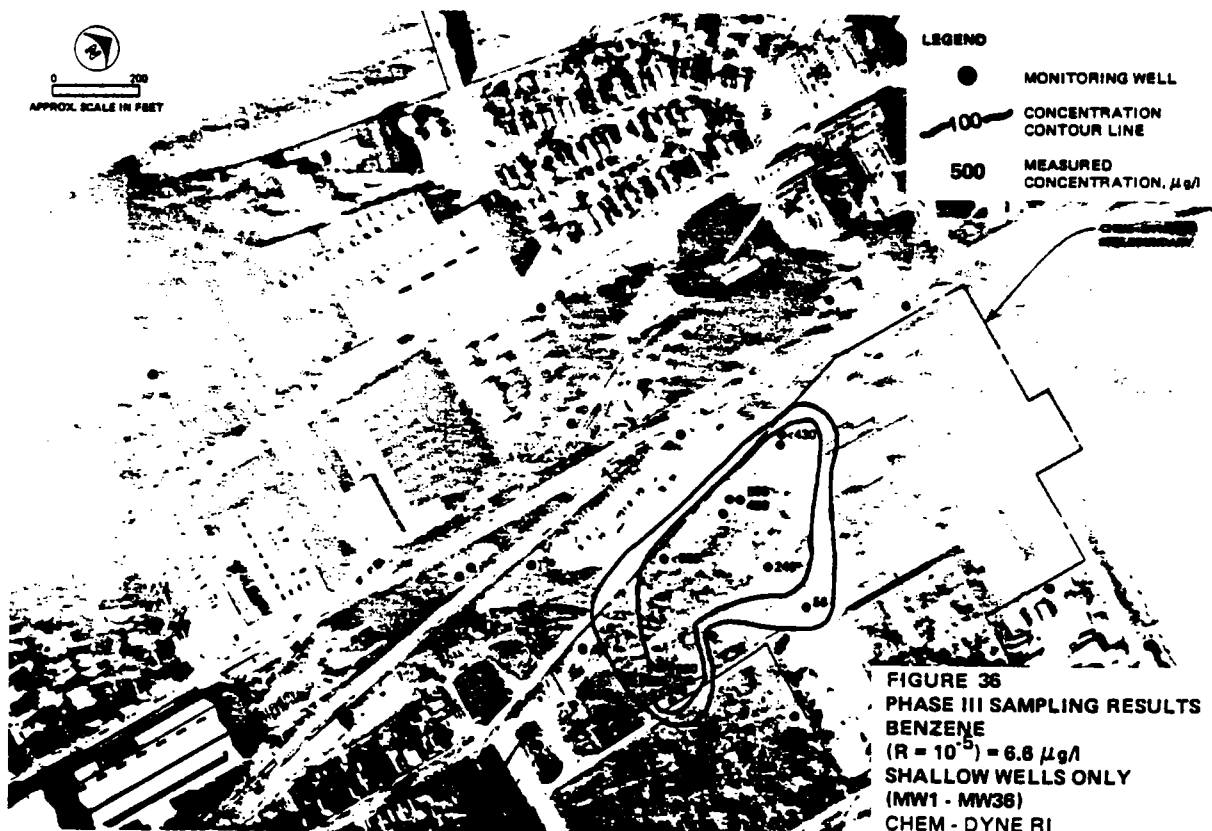
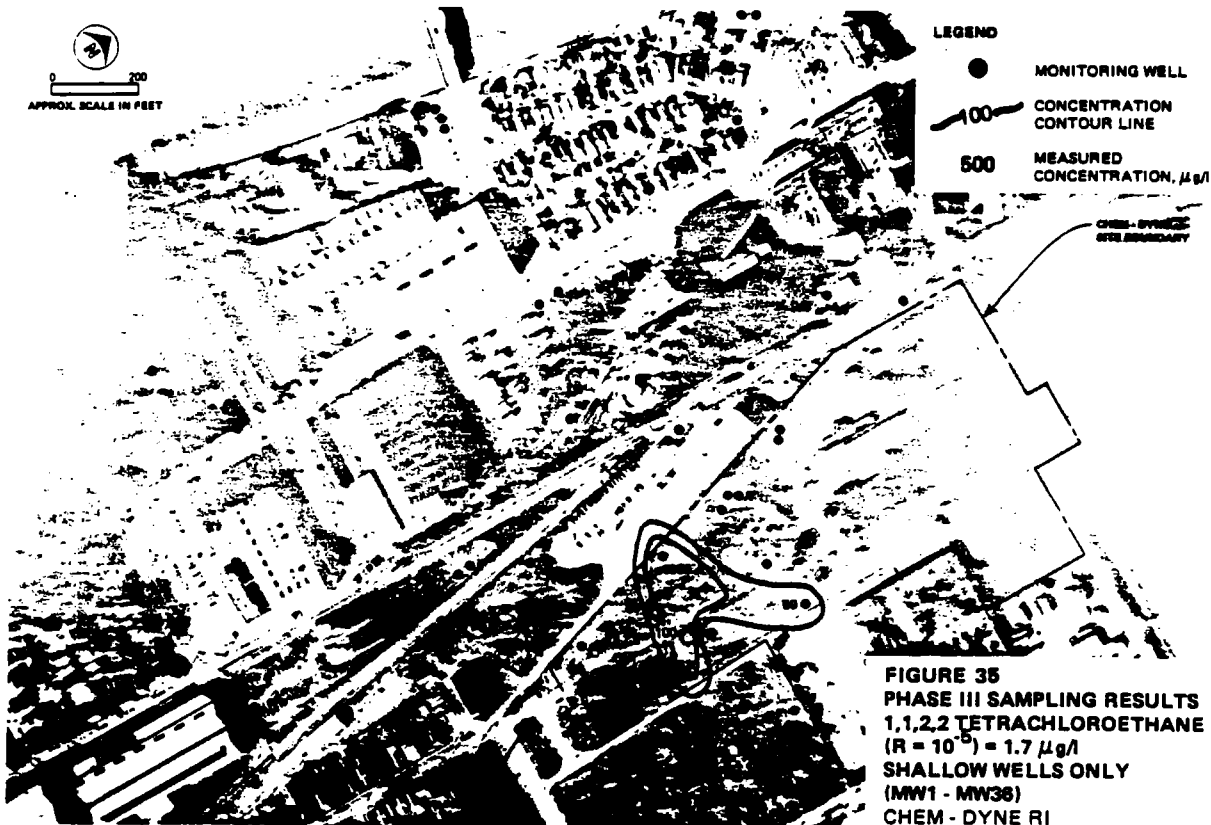
FIGURE 28  
PHASE III  
(OCTOBER 1983)  
TOTAL VOC'S  
SHALLOW WELLS ONLY  
CHEM - DYNE RI







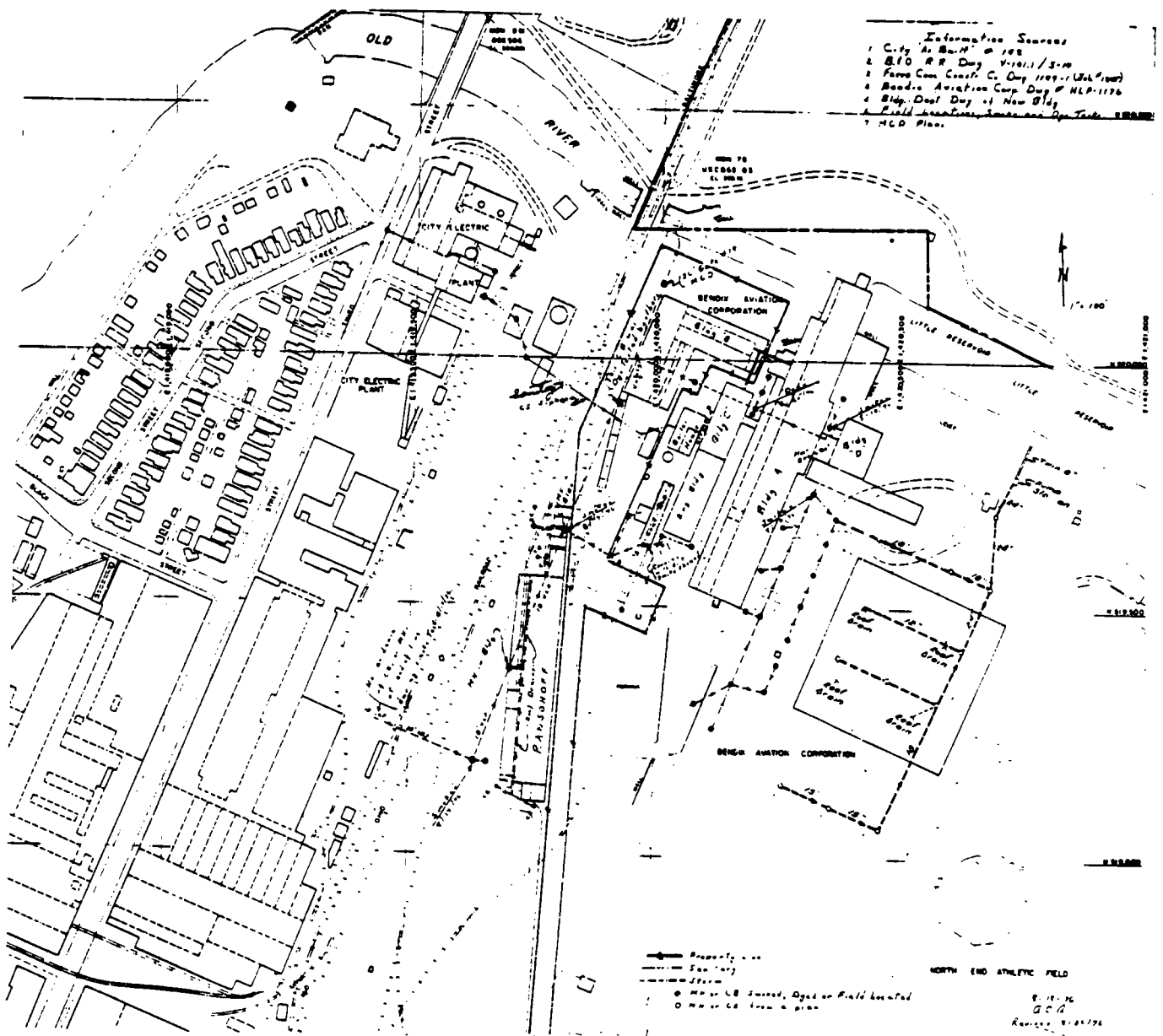




- o The compound in highest concentration at the fringes of the VOC plume (MW-18, MW-30 and MW-4) is also trans-dichloroethene.
- o In addition to trans-dichloroethene, TCE, 1,1-dichloroethene, vinyl chloride and 1,2-dichloroethane are present in the fringe wells suggesting that these compounds are transported more rapidly than others and provide indicators of the lateral extent of the plume. With the exception of TCE, those VOC's tend to have high water solubilities, low molecular weight, and low octanol-water partition coefficients (refer to Table 18).
- o Four of the five VOC's found in the fringe wells are chlorinated ethenes.
- o Benzene occurs in a relatively even distribution at concentrations generally between 200 and 500 ug/L across the site.
- o Chloroform occurs as three apparently separate areas of high concentrations.

Several explanations for the separate high concentration areas exist. The high concentration area near MW-15 is very near the sanitary sewer line, shown in Figure 37, which runs westward from the site to the interceptor in Third Street. This sewer line passes below the railroad tracks through an inverted siphon. If waste solvents were dumped into a basement toilet as reported in police records cited by the Journal News November 28, 1979, large volumes of waste may have been trapped in the inverted siphon and other portions of the sewer and leaked into the unsaturated zone. The high concentration area near MW-15 may also be caused by exfiltration from steam tunnels near the Chem-Dyne building that were reportedly used for waste dumping (personal correspondence Dr. E. Meyer, Meyer Environmental Consultants). Wastes were also reportedly pumped over the site fence toward the N&WRR tracks. Surface soil samples SS-10 collected outside the north-west margin of the site and near the N&WRR tracks contained many of the VOC's identified in groundwater samples from well MW-15. The high concentration area near MW-10 may be the result of reported waste solvent dumping on open ground.

The high VOC concentrations in MW-15 groundwater samples cannot be related to runoff or leachate from the coal storage piles in the vicinity. Extensive sampling and analysis of coal mining industry wastewater by U.S. EPA (Ref EPA 440/1-82/057) demonstrated that chlorinated VOC's of the



**FIGURE 37**  
**MAP OF EXISTING SEWERS**  
**CHEM-DYNE**

variety found in the groundwater at the Chem-Dyne site rarely are detected and at only low ug/L concentrations.

Contamination patterns of the chlorinated ethenes (TCE, dichloroethene, and vinyl chloride) as shown on Figures 27, 28, 29, and 32 suggest that dechlorination transformations may occur in the upper aquifer VOC plume. Considering only Phase III groundwater data, it appears that TCE is in high concentration at MW-10 onsite but the concentration is substantially lower only 250 feet away at MW-13. However, considering the same data, the concentration of trans-dichloroethene in offsite wells MW-13 and especially MW-34 is rather high although still less than the concentration at MW-10; vinyl chloride concentration in offsite well MW-34 is substantially higher than at onsite well MW-10. Similarly, 1,1-dichloroethene is not identified at MW-10 yet was found in offsite well MW-34 at 1,200 mg/l. These data suggest that TCE is potentially being successively dechlorinated to dichloroethenes and vinyl chloride.

The observation of possible dechlorination behavior in the VOC contamination at Chem-Dyne is in accord with recent literature. Laboratory experiments by Parsons, et al with selected microcosms have demonstrated biologically mediated dechlorination of tetrachloroethene to TCE, dichloroethenes, and vinyl chloride. The reported identification of vinyl chloride at 2,400 ml/l in a 55-foot deep monitoring well in Suffolk County, New York in 1983 was attributed to the possible breakdown (dechlorination) of tetrachloroethene and TCE by Sy Robbins, County Hydrogeologist (6). These reports, among others, support the possibility that the widespread occurrence of trans-dichloroethene and the somewhat unexpected occurrence of vinyl chloride in the groundwater contamination at Chem-Dyne may be the result of in-situ dechlorination of the more "typical" raw VOC wastes, tetrachloroethene and TCE. The identification of cis-dichloroethene, a reported TCE dechlorination product, would further support this possible explanation of the observed contamination pattern. However, the CLP currently does not report cis-dichloroethene for routine organic analysis samples.

Explanation for the VOC contamination patterns must be tempered by the following considerations:

- o The original waste VOC mixture(s) are unknown and probably cannot be known since VOC's were introduced to the groundwater system over a period of several months and from a wide variety of sources at Chem-Dyne.
- o The groundwater VOC data is not supported with any other data such as microcosm studies, soil TOC, groundwater dissolved oxygen or redox potential, etc., which could be used to explore biological degradation, sorption, and abiotic dechlorination

in more detail. Velz summarized the current case for biologically mediated VOC breakdown as follows: "...one can seemingly make a case for in situ biodegradation of highly chlorinated 2-carbon aliphatics and olefins in some ecosystems contaminated with certain chlorinated solvents. In contrast, there is also current data suggesting that such biodechlorinations are not effective in decreasing similar aquatic contaminations. However, much of the current information is both tentative and speculative and efforts to establish substantive conclusions should be tempered with caution."

- o Other possible explanation for the observed VOC contamination patterns exist, including slug flow of contaminants and variable sources or releases.

VOC contamination has been identified in some samples from the deep monitoring wells, which are approximately 65 feet deep with 10 feet of screen section. Total VOC concentrations for wells MW-26, MW-28, MW-12, and MW-33 from Phase III samples are shown in Figure 38. Specific VOC's identified at MW-28 and MW-33, where the total concentration is highest, are as follows:

<u>Monitoring Well</u> <u>MW-28</u>	<u>Monitoring Well</u> <u>MW-33</u>
Benzene	1,2-dichloroethane
Ethylbenzene	1,1-dichloroethane
Tetrachloroethene	1,1,2-trichloroethane
Vinyl chloride	1,1-dichloroethene
Trans-dichloroethene	Trans-dichloroethene
	Vinyl chloride

Two observations can be noted from comparison of compounds found in these samples. First, the mixture of compounds is not the same in each well. Second, both samples contained trans-dichloroethene and vinyl chloride which may be products of the successive dechlorination of tetrachloroethene and/or TCE.

VOC contamination of a deeper portion of the aquifer indicates that the contaminant plume could be drawn into the production wells in the vicinity, especially at the City of Hamilton power plant, which could become contaminated also. However, analysis of production wells at the municipal power plant and Beckett Paper have not shown evidence of contamination. Results from Phase III samples collected at Champion Paper wells, Nos. 1 and 4, indicated trace concentrations (2 to 4 ug/L) of 1,1,1-trichloroethane, trans-dichloroethene and trichloroethene.

The observation of 1,1,1-trichloroethane, trans-dichloroethene, and trichloroethene in Champion Paper wells merits additional



discussion. These compounds could be from the site for the following reasons:

- o Both trans-dichloroethene and TCE are compounds found in the fringe monitoring wells and both appear to be among the most mobile VOC's.
- o Trans-dichloroethene was found at 1,200 ug/L in the deep well MW-33 which is directly across the Great Miami River, about 600 feet from the riverbank.
- o Data from continuous water level measurements at deep wells MW-19 and MW-32 before the pump test, indicated a hydraulic connection beneath the river between the monitoring wells and a pump suspected to be Champion Well No. 1.
- o Detection of the three compounds was in the last sample taken from the wells in October suggesting the first signs of contamination not present during Phase II sampling in June.

These compounds may not be contaminants from the site for the following reasons:

- o None of the compounds are detected in the deep wells MW-19 and MW-32 near the river, directly between MW-33 and Champion Well No. 1 nor in deep well MW-22 near the Ford Canal.
- o The compounds are rather common industrial solvents, especially TCE, and could originate from an upgradient source on the west side of the river.
- o TCE and 1,1,1-trichloroethane which were found in the Champion Paper samples were not identified in MW-33 that did show trans-dichloroethene. Further, vinyl chloride which was a major component of the VOC mixture identified at MW-33 was not identified in the Champion Paper well samples.

In summary, three chlorinated VOC's were identified in trace concentrations in Champion Paper Wells No. 1 and 4 in samples taken in October 1983. The compounds are among the known contaminants in groundwater at the Chem-Dyne site. However, there are reasons to believe that these VOC's could be from other sources unrelated to the site.

Correlation of total VOC concentrations with groundwater elevations for each of the three sampling efforts suggests that most of the VOC contamination in the upper aquifer occurs in the top 4 to 6 feet of the water table at the two

wells with consistently high concentrations, MW-10 and MW-15. Table 19 summarizes the total VOC concentration data for nine monitoring wells with water column depth at each sampling.

The observation above is based on the correlations of low water table elevations with generally higher total VOC concentrations. An interpretation is as follows: when the water table is low, VOC concentration is high because the wells intercept the high-concentration top portion of the aquifer; with rising water table, the wells intercept both the high-concentration uppermost groundwater and more dilute lower portions of the aquifer. VOC samples were collected with a bottom-filling bailer an integrated water column produced by purging. Therefore, low water table should correlate with high VOC concentrations and higher water table (interpreted as more dilution) should correlate with lower VOC concentrations. This overall trend is observed, particularly in MW-10 and MW-15.

In general, volatile organic compounds are very persistent (nonbiodegradable). The compounds usually have low acute toxicity. However, several of the compounds are suspected carcinogens and many of the water quality criteria are based on carcinogenicity protection. Commonly referenced toxicity information is summarized in Table 20.

#### GENERAL CONCLUSIONS AND OBSERVATIONS

Evaluation of the aquifer characteristics with the inorganic and organic groundwater data can be summarized as follows:

- o In general, the geologic information from boring logs and monitoring well installation, the aquifer hydraulic properties determined from the pump test, and the direction of movement and extent of contamination of the aquifer give a consistent picture of the physical situation and properties at the Chem-Dyne site.
- o Boring logs indicate the presence of a silt/clay layer near MW-12 and MW-13, near MW-8 and MW-9 and near the Great Miami River.
- o The results of the aquifer pump test provided a range of values for transmissivity and storage coefficients, from  $0.3 \times 10^5$  gpd/ft to  $7 \times 10^5$  gpd/ft for transmissivity and 0.0009 to 0.32 for storage coefficients. Most of the values for transmissivity fall within a much narrower range of  $1 \times 10^5$  gpd/ft to  $3 \times 10^5$  gpd/ft. Higher values of transmissivity are generally toward the west and southwest.

Table 19  
SUMMARY OF TOTAL VOLATILE CONCENTRATION AND WATER COLUMN DEPTH

Monitoring Well	(Screen Length ft)	FIT April 1981		Roy F. Weston December 1982 Total VOC, ug/l	Phase II June-July 1983		Phase I April 1983		Phase III October 1983	
		Total VOC, ug/l	Depth W.C. ft		Total VOC, ug/l	Depth W.C. ft	Total VOC, ug/l	Depth W.C. ft	Total VOC, ug/l	Depth W.C. ft
MW-4	(9)	1,840	3.30	3,372 <sup>a</sup>	800	8.16	1,810	4.52	1,823	2.92
MW-5	(11)	374	5.62	-	798	8.29	1,658	7.29	677	5.64
MW-6	(11)	27,530	1.87	-	16,500	4.86	20,520	3.61	22,276	1.78
MW-7	(8)	33,840	3.40	800	12,210	8.42	8,462	4.96	11,990	3.21
MW-9	(11)	511	6.50	3 <sup>a</sup>	2,120	9.97	1,650	5.39	1,015	4.10
MW-10	(8)	115,576	7.98	68,020 <sup>a</sup>	35,000	10.32	74,270	8.24	130,000	6.49
MW-13	(10)	3,424	2.23	1,533 <sup>a</sup>	90	6.65	460	3.81	10,800	2.06
MW-15	(10)	-	-	120,750	15,000	11.67	75,514	8.00	88,500	7.67
MW-18	(10)	350	5.41	952	980	9.59	1,213	6.59	832	5.09

<sup>a</sup> Average total VOC concentration from multiple samples.

**Table 20**  
**SUMMARY OF WATER QUALITY CRITERIA AND SNARLS FOR PRIORITY POLLUTANT VOC'S**

<u>Volatile Organic Priority Pollutant Compounds</u>	<u>Water Quality Criteria, ug/l<sup>a</sup></u>			<u>SNARL, ug/l<sup>b</sup></u>	
	<u>Water Ingestion Toxicity Protection</u>	<u>Water Ingestion Cancer Protection (1 of 100,000)</u>	<u>Lowest Chronic Freshwater Toxicity</u>	<u>10-Day</u>	<u>Long-Term</u>
Benzene		6.6	NDA	-	70
Carbon tetrachloride		4.0	NDA	200	-
Chlorobenzene	488		NDA		
1,2-dichloroethane		9.4	20,000		
1,1,1-trichloroethane	18,400		NDA	-	1,000
1,1-dichloroethane	NCA		NDA		
1,1,2-trichloroethane		6.0	9,400		
1,1,2,2-tetrachloroethane		1.7	2,400		
Chloroethane	NCA		NDA		
Chloroform		1.9	1,240		
1,1-dichloroethene		0.33	NDA	1,000	70
trans-dichloroethene	NCA		NDA	2,700	-
1,2-dichloropropane	NCA		5,700		
Ethylbenzene	1,400		NDA		
Methylene chloride		1.9	NDA	13,000	150
Tetrachloroethene		8.0	840	2,300	20
Toluene	14,300		NDA	21,500	340
Trichloroethene		27	NDA	2,000	75
Vinyl chloride		20	NDA		

<sup>a</sup> U.S. EPA Water Quality Criteria.

<sup>b</sup> U.S. EPA Health Advisories (formerly known as Suggested No Adverse Response Levels - SNARLS).

- o Groundwater flow directions are across the site and downward from area near well Nos. MW-1, MW-2, and MW-3 toward the west and southwest. Higher transmissivity values near the river and higher values of transmissivity parallel to the river may divert flow more toward the south. Conversely, strong vertical flow components and the impact of the Champion Paper Company's wells on the west side of the river indicate groundwater flow is moving to the west underneath the river. The direction of movement of the contaminated groundwater plume indicates westward and downward flow beneath the site and toward the Champion wells is the predominant direction of flow. However, the lack of sampling points in the southwest area and in the deeper portions of the aquifer do not allow the alternate more southerly flow path to be evaluated in detail.
- o Rates of groundwater flow based on an assumed porosity (N) of 0.30, a gradient (I) of 0.002 and an average hydraulic conductivity (K) of 1,100 gpd/ft<sup>2</sup> or 147 ft/day are:  $V = KI/N = 0.98$  ft/day. If the porosity and gradient are assumed to be relatively constant and the greatest range of transmissivities provides for a range of groundwater velocities from 0.15 ft/day to 3.5 ft/day. Because of the limitations on the data from the pump test the upper and lower bounds for this range are suspect. The most reliable data indicate the range for groundwater velocities is between 0.5 ft/day to 1.5 ft/day.
- o Generally, the observed distribution of VOC contamination agrees well with the expected distribution based upon aquifer conditions, such as direction of groundwater flow and geologic heterogeneity.
- o Under stress during the pump test, MW-13 data suggested the presence of a semiconfining layer in the vicinity.
- o Pump test results indicated that there is not a good hydraulic connection between the pumped well and the area near MW-26 and MW-15 (correlates with observed separation between contaminant plumes demonstrated by concentration plots).
- o Concentrations of barium, iron, manganese, and boron appear consistently higher in the vicinity of the site and lower in samples farthest from the site.

- o Inorganics found in greater concentrations than Interim Primary Drinking Water Standards are barium, lead, and mercury.
- o Inorganics found in greater concentrations than recommended secondary drinking water standards are manganese, iron, and zinc.
- o Organic groundwater contamination consists almost entirely of VOC's that are mobile and persistent. The contaminant plume is best defined by the extent of VOC's.
- o The VOC plume has two distinct areas of very high concentrations relative to the overall plume. The apparent separation of the two areas of high concentration may be hydraulically induced (poor hydraulic connection) or may be related to separate sources of contamination.
- o Several causes for the high VOC concentrations are possible. The sources of contamination near MW-15 may have been the sanitary sewer from the site, steam tunnels, and waste spraying toward the N&WRR tracks. Contamination near MW-10 may be the result of surface dumping.
- o Based on the correlation of groundwater surface elevation and total VOC concentrations, most of the VOC contamination in the surface aquifer appears to be in the upper 4 to 6 feet of the water table.
- o VOC contamination has spread to a depth of at least 65 feet in the aquifer.
- o VOC contamination, typical of known site contamination compounds, was detected in October 1983 samples from two Champion Paper's wells.
- o Four of the five VOC's identified at the outer edge of the plume are chlorinated ethenes.

#### ONSITE FACILITIES

The onsite facilities include the building structures and appurtenances and utilities. The major buildings are the Chem-Dyne, boiler, Ward Manufacturing, Ford factory, and the blue warehouse. Several other small structures include a coal bunker, garage, scale house, and pump house. Except for the blue warehouse building all of the onsite structures are in deteriorating or dilapidated condition. The blue warehouse is a relatively new metal structure in generally good condition.

In addition, the onsite facilities include two partially buried, cylindrical tanks that were used to receive and mix waste chemicals. Also, OEPA personnel suspect buried tanks may be present just east of the Ford Factory Building. However, their presence has not been confirmed.

Onsite utilities include sanitary and storm sewers, water supply line, electrical and natural gas service lines. All utilities onsite are reportedly out of service.

Locations of the facilities are shown in Figure 39.

#### FACILITIES INVENTORY

In October 1983, each of these facilities was visually inspected for general condition and evidence of contamination. Detailed observations of this inspection are given in the photographic log attached to the TM for Subtask 3-7. Inspection observations are summarized below.

##### Chem-Dyne Building

Observations and the results of samples taken from the floor of the Chem-Dyne building north of the loading dock, indicate contamination with a variety of chemical wastes. Trash is scattered throughout all areas. A portion of the east side of the building is badly damaged from a fire in April 1983. The building is generally in disrepair with numerous broken windows, but major structural distress is generally limited to the fire-damaged areas. Building entry is virtually unrestricted.

##### Boiler Building

The boiler building first floor is covered with debris and sections of the collapsed second story floor. No chemical contamination was visually apparent on the first floor. However, in the basement floor, an electrical conduit which penetrated the south wall was draining suspected contaminated fluids onto the floor. Head space within the conduit contained over 100 ppm organic vapor measured with an HNu using a 10.2 eV probe calibrated to benzene. Building entry is virtually unrestricted. The building is in extreme structural distress.

##### Ward Manufacturing Building

The Ward Manufacturing Building contained scattered debris but no visual evidence of contamination. Building entry is virtually unrestricted. Major structural distress or collapse was not observed although the building is in a deteriorating condition.

1) THIS MAP IS A COMPOSITE MAP INDICATING THE APPROXIMATE LOCATION OF EXISTING STRUCTURES AND UTILITIES

2) ALL LOCATIONS SHOULD BE FIELD VERIFIED

3) THE FOLLOWING DRAWINGS WERE USED TO MAKE UP THIS MAP

**A) SANITARY DESIGN**

**CITY OF HAMILTON AS BUILT NO 142**  
**CITY OF HAMILTON SEWER LOCATION**

### B) STORM SEWERS CITY OF HAMILTON SEWER LOCATION

**CI WATER CITY OF HAMILTON UTILITY DRAWING D 5**

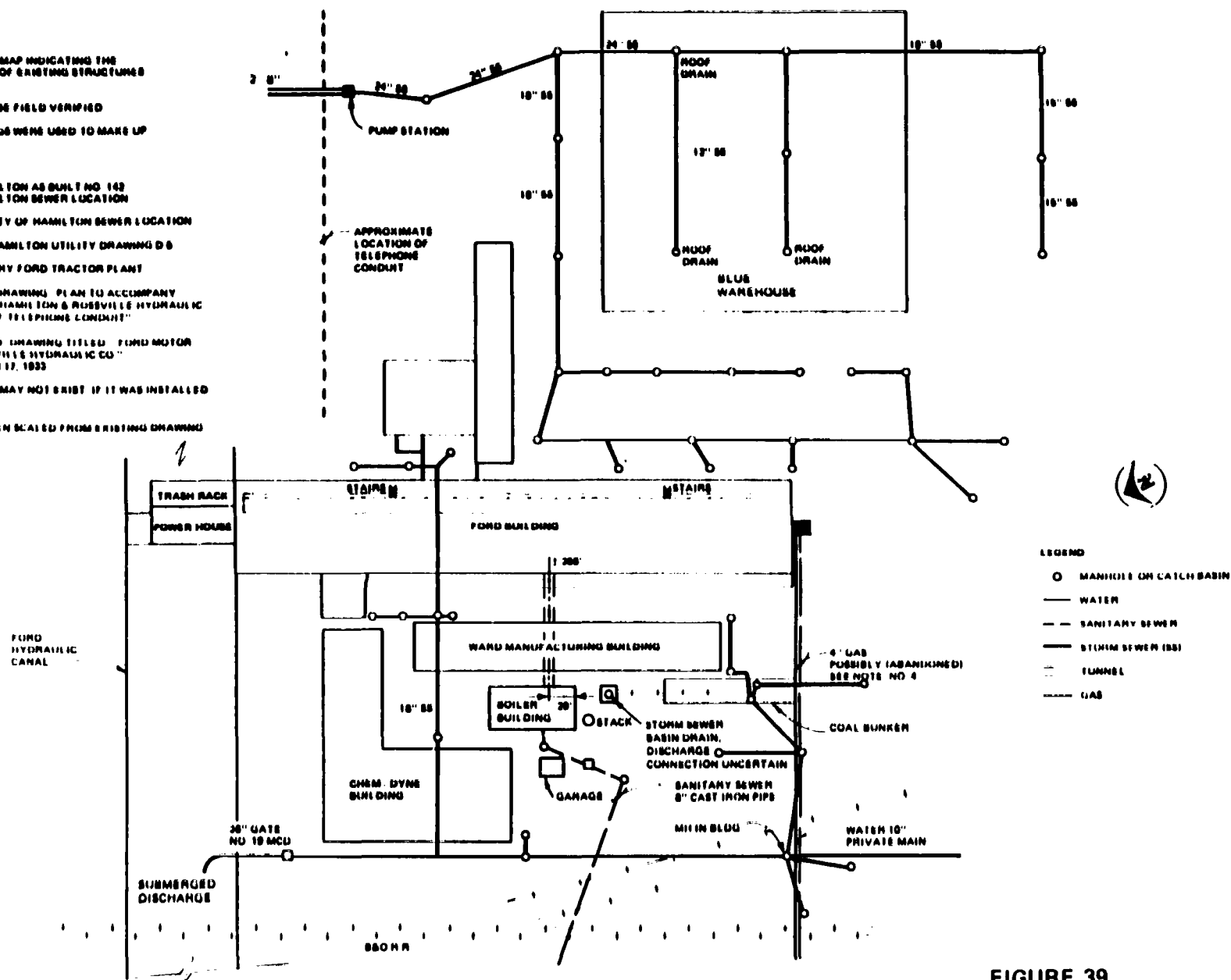
(U) GAS PLAN OF HENRY FORD TRACTOR PLAN!

81 TELEPHONE MANUFACTURING PLANT TO ACCOMPANY  
ALIGNMENT WITH HAMILTON & RUSSELL HYDRAULIC  
LIFT FOUNDATION, OF TELEPHONE COMPANY"

PI TUNNEL IN ALIEN DRAWING TITLED "PUMP MOTOR  
(1) AMERICAN RUBBERVILLE HYDRAULIC CO."  
DIVISION MARCH 17, 1953

4) THE 4" GAS LINE MAY OR MAY NOT EXIST IF IT WAS INSTALLED  
IT HAS BEEN ABANDONED

8) ALL LOCATIONS HAVE BEEN SEALED FROM RISING CHANNING  
NOTED ABOVE



**FIGURE 39**  
**COMPOSITE UTILITY MAP**  
**CHEM - DYNE RI**

### Ford Factory Building

The Ford factory building did not visually appear to be contaminated. However, the ground floor is readily accessible through large doors and offers a large sheltered storage area. Although no significant amounts of Chem-Dyne waste are known to have been stored in this building, it is reasonable to suspect that waste drums may have been stored in the Ford Building.

The basement and ground floors are strewn with miscellaneous debris. The upper floors are relatively clean. Major structural distress was not observed although the building is in generally deteriorating condition.

### Blue Warehouse

Drummed wastes were reportedly stored both in the warehouse and on the south parking lot. Drum rings were observed at both locations. In addition, several areas of what looked like fly ash spread out as sorbant were observed on the warehouse floor suggesting previous spillage.

Building entry is somewhat restricted but still relatively easy through breaks in the metal siding and windows. The warehouse appears to be in good condition structurally.

### Garage

The relatively small garage to the south of the Chem-Dyne building is known to have been used for waste storage and the floor is visibly contaminated.

The building is in a deteriorating condition with unrestricted entry.

### Onsite Utilities

Known onsite utilities include the following:

- o Storm sewers
- o Water supply line
- o Sanitary sewer
- o Electrical conduit (private lines only)
- o Natural gas line
- o Electrical utility lines (suspended overhead on poles)

The locations of these utilities are shown in Figure 39.

### Buried Tanks

The two cylindrical metal tanks, approximately 15 feet in diameter, are exposed at the ground surface in the north-central portion of the site. The tanks are partially filled with gravel. Reportedly, liquid wastes were emptied into these tanks and allowed to drain into subsurface soil. The depths of these tanks are unknown and protective covers have been placed to restrict precipitation access. Presently, there are no other confirmed buried tanks. OEPA personnel suspect additional buried tanks may be present just east of the Ford factory building.

#### DESCRIPTION OF SAMPLING

Samples from buildings and appurtenances were collected from the coal bunker, Chem-Dyne building floor, and soil below the blue warehouse parking lot during the RI activities in 1983.

Sampling of utilities was limited to one water sample from the storm sewer and one measurement of the headspace inside the electrical conduit penetrating the south wall of the boiler building basement. These data are presented in more detail in the TM's listed below:

<u>Facility Sample</u>	<u>TM Reference</u>
Coal bunker soil	Subtask 3-1
Chem-Dyne floor samples	Subtask 3-4
Blue warehouse parking lot soil	Subtask 3-4
Storm sewer water	Subtask 3-1
Electrical conduit headspace	Subtask 3-7

#### EVALUATION OF BUILDING SAMPLE DATA

##### Coal Bunker "Soils"

In April 1983, two near-surface "soil" samples were collected, one about 50 feet south of the north wall of the coal bunker and the other about 75 feet further south. These samples were designated as SS-7 and SS-6, respectively.

Inorganic Analysis. Compared to results from other onsite soil, high concentrations of chromium, barium, cadmium, iron, lead, arsenic and tin were identified. Iron, lead, and arsenic have been reported as common leachable metals from crushed coal. Inorganic analysis may reflect elevated concentrations due to residual contamination from past coal storage. However, arsenical sludges are known to have been stored in this bunker during Chem-Dyne operations.

Organic Analysis. Fifteen chlorinated VOC's were identified. Concentrations in SS-6 were all less than 0.50 ug/kg while concentrations in SS-7 ranged generally 10 and 100 ug/kg. None of these compounds is a typical component of coal pile runoff and each has been identified in groundwater samples with the exception of bromodichloromethane.

Five pesticides, chlordane, dieldrin, 4,4'-DDE, endrin, and endosulfan sulfate, were identified. Chlordane was found at 580 mg/kg in SS-7 while all other compounds were found at less than 30 mg/kg. All of these materials are considered persistent and toxic. Endosulfan sulfate is noteworthy because it was not detected in any of the other near-surface soil samples obtained during the April sampling. It was identified at other onsite locations by FIT sampling in 1981 and one sample collected during the RI final soil investigation.

The following general base/neutral compounds were identified:

- o chlorinated benzenes
- o phthalates

In addition, hexachloroethane, isophorone, and naphthalene were found. All compounds were found at less than 250 mg/kg except phthalates. Bis (2-ethylehexyl) phthalate occurred at 970 mg/kg.

PCB-1260 was reported in soil sample SS-7 at 93 mg/kg as identified by two column chromatography. At this concentration, the "soil" would require disposal at a secure landfill approved for PCB's. PCB's were not detected in sample SS-6.

#### Chem-Dyne Building Floor Samples

In September 1983, two grab samples were collected from the floor in the high bay area of the Chem-Dyne building directly north of the loading dock area. The samples consisted of the viscous sludge-like material typical of the contamination found across large areas of the floor. The appearance of the floor contamination is marked by several distinct colors including bright green (apparently fluorescence) and deep purple.

Inorganic Analysis. Several elements were found in relatively high concentrations. Iron and zinc were in highest concentration for both samples while copper was found at 13,500 mg/kg in one sample. Other elements distinguished by higher concentrations were chromium, barium, boron, vanadium, and arsenic.

Organic Analysis. Three volatile compounds were identified in the samples. The most abundant compounds, tetra-chloroethene, was found at 60 mg/kg. As suspected, few volatile compounds were detected in these samples which were taken directly from the floor.

The following three general groups of base/neutral compounds were found:

- o Chlorinated benzenes
- o Polynuclear arcatics (PNA's)
- o Phthalates

The chlorinated benzenes included m- and p-dichlorobenzene and hexachlorobezene. These compounds are associated with pesticide wastes. The PNA's include benzo(a)anthracene, benzo(k)flouranthene, and chrysene which are recognized as animal carcinogens and suspected as human carcinogens. PNA's originate from a variety of materials such as fuel oil and coal tar as well as chemical wastes.

Two pesticides, endrin and dieldrin, were identified at less than 300 ug/kg. Both pesticides are known to have been in wastes stored onsite.

One grab sample was found to contain 90 mg/kg PCB, reported as PCB-1248. This is significant because, at this concentration, PCB's require disposal in an approved secure landfill. If PCB contamination is more concentrated (>500 mg/kg), incineration is required for disposal.

Phthalates found in the floor samples include bis (2-ethylhexyl) phthalate, found elsewhere in the surface soil samples.

#### Blue Warehouse Parking Lot

In September 1983, two grab samples were collected from base material below the asphalt parking lot south of the blue warehouse. The purpose of these samples was to determine if contamination occurred because of drum leakage during the period that the lot was used for drum storage.

Inorganic Analysis. In comparison with concentrations determined in offsite soil samples, the following elements were found at elevated concentrations: iron, barium, cadmium, cooper, lead and tin.

Organic Analysis. Of the four VOC's identified, chlorobenzene was found in the highest concentration at 62 mg/kg in sample GS-5 where the head space VOC measurement was 100 to 150 ppm.

Similar to the Chem-Dyne building samples, chlorinated benzenes and phthalates were identified in the base/neutral fraction.

Two atypical base/neutral priority pollutant compounds were also identified, 3,3'-dichlorobenzidine and N-nitrosodiphenylamine, at concentrations of 32 and 33 mg/kg respectively. These compounds merit attention because 3,3'-dichlorobenzidine and N-nitrosodiphenylamine are potent animal carcinogens and suspected human carcinogens. Because of the chlorinated and amine portions of both molecules, neither can be related to the asphalt material used for paving.

In the same sample with the 3,3'-dichlorobenzidine, 18 mg/kg of PCB, reported as PCB-1248, was also identified. Combined with the two base/neutral compounds discussed above, the PCB contamination strongly indicates contamination of the soil beneath the parking lot south of the blue warehouse.

#### EVALUATION OF UTILITY SAMPLE DATA

##### Storm Sewer Water

A storm sewer main, that intersects storm sewer lines from the northwestern portion of the site, discharges into the lower Ford Canal near the northwest corner of the site (see Figure 37). In April 1983, a sample of the storm sewer drainage was collected at the valve vault in the Ford Hydraulic Canal south level. The valve was closed but enough water was leaking past the valve to yield a 2 gallon sample within a few hours.

Inorganic Analysis. Boron was found in a concentration of 900 ug/L which is higher than any concentration found in groundwater samples. Other elements found at elevated concentrations were manganese and zinc although concentrations in the drainage water were comparable with groundwater concentrations.

Organic Analysis. Nine volatile priority pollutant compounds were identified in measurable concentrations. All VOC's were compounds commonly found in the mixture of groundwater contaminants. Of the nine VOC's, the following six were found in concentrations exceeding the Water Quality Criteria (WQC) for carcinogenicity protection against 1 in 100,000 persons:

- |   |                           |   |                   |
|---|---------------------------|---|-------------------|
| o | 1,2-dichloroethane        | o | Chloroform        |
| o | 1,1,2-trichloroethane     | o | Tetrachloroethene |
| o | 1,1,2,2-tetrachloroethane | o | Trichloroethene   |

The VOC 1,2-dichloroethane was identified in the highest concentration at 33 ug/L.

Two pesticides, endrin and dieldrin, were identified at 0.05 and less than 0.05 ug/L respectively. These pesticides are known to have been in wastes stored at the site. Dieldrin is a suspected carcinogen and endrin is a very toxic compound for freshwater biota. Both compounds are considered to be highly persistent according to 40 CFR 300, Table 5.

#### Electrical Conduit Headspace

During the facility inspection on October 1983, an electrical conduit which penetrated the south wall of the boiler building basement was observed draining contaminated fluids onto the floor. An accumulation of colored residue was noted along the wall and on the floor below the conduit. The inspection was done in level "B" personnel protection therefore no odor could be noted.

The headspace inside the conduit was measured for organic vapors with an HNu equipped with a 10.2 eV lamp calibrated to benzene. Organic vapors were measured at over 100 ppm benzene equivalent in the headspace.

The observation of contaminated electrical conduit and storm sewer discharges strongly suggests that other onsite utility piping may be contaminated and may act as routes for rapid spread of contaminants.

#### GENERAL CONCLUSIONS AND OBSERVATIONS

Conclusions regarding the onsite facilities can be summarized as follows:

- o The floor of the Chem-Dyne building is obviously contaminated with chemical wastes. Endrin, dieldrin, and PCB's (reported as PCB-1248) have been identified.
- o Access to the Chem-Dyne building is practically unrestricted once inside the site fence.
- o The relatively small garage to the south of the Chem-Dyne building was used for waste material storage and the floor is visibly contaminated.
- o Seepage into the basement of the boiler building through an electrical conduit is contaminated with VOC's based on headspace measurements.
- o The blue warehouse was used for drummed waste storage. Scattered areas of flyash were found on

the floor in areas marked with drum rings. This material may have been used to sorb spilled waste.

- o The storm sewer discharges very low concentrations of endrin into the Ford Canal.
- o Chemical contamination was found in soil immediately beneath the asphalt in the blue warehouse south parking lot. Three notable compounds are PCB (reported as PCB-1248), 3,3'-dichlorobenzidine, and N-nitrosodiphenyl amine none of which could be related to asphalt residue.
- o Additional hazard is presented by the extreme structural distress of some buildings, particularly the Chem-Dyne and boiler buildings. The relative ease of access to the building interiors compounds this hazard.

#### FORD CANAL

The Ford Hydraulic Canal water and sediment were sampled in April 1983 and in September 1983. Both sets of samples were analyzed for the inorganic and organic priority pollutants and other constituents in the routine CLP analytical packages. Data on the canal samples must be evaluated with some caution because of the possible effect of contamination from Gann's junkyard located approximately one mile upstream of the site. Gann's junkyard was an unregulated site from which approximately 1,800 drums containing alcohols, paint waste, phenolic and melamine resins were removed during the late 1981 and early 1982.

In addition to the water and sediment analysis, several fish tissue samples were also analyzed for pesticides and PCB's. These data will be included in the discussion.

The technical memorandums referenced in this section are as follows:

<u>Sample</u>	<u>TM Designation</u>
Canal water	Subtask 3-1
Canal sediment	Subtask 3-1 (April)
	Subtask 3-2.5 (September)
Canal fish	Subtask 3-2.5

#### FORD CANAL WATER

Two samples of canal water were taken in April, one upstream, east of the hydroelectric plant, and one downstream immediately west of the railroad bridge piers. Both samples were taken from the south side of the canal. One sample of canal water and three samples of Great Miami

River water were taken in September. The canal sample was taken near the south bank, downstream of Third Street. The Great Miami River samples were taken from the following three locations:

- o Mid-river upstream of the Ford Hydraulic Canal and approximately 200 feet downstream of the spillway (Sample GMR-001).
- o Mid-river, downstream of the Ford Canal, approximately midway between the Ford Canal and the highway bridge (Sample GMR-002).
- o Mid-river, downstream of the Ford Canal, approximately 300 feet north of the highway bridge (Sample GMR-003).

#### Inorganic Analysis

Comparison of upstream and downstream canal water data from April reveals no difference in the concentrations of any elements except mercury. The downstream mercury concentration was reported as 2.25 ug/L which is 10 times the upstream concentration. Downstream water sampled in September had a mercury concentration of 0.2 ug/L. A summary of inorganic data for the samples collected in September is shown on Table 21.

#### Organic Analysis

Upstream and downstream samples from April showed practically no priority pollutant organics except toluene which was identified in the upstream and downstream water at about 5 ug/L, the detection limit.

The canal and Great Miami River samples from September indicated that 1,1,1-trichloroethane were present in canal water and in the river water downstream from the canal. Trichloroethane was not detected in river water upstream of the canal. Methylene chloride was identified in both field blanks, therefore, methylene chloride cannot be demonstrated as a surface water contaminant.

#### **FORD CANAL SEDIMENT**

One downstream sample of canal sediment was collected in April 1983 along the south shore immediately east of the Municipal power plant water intake. No upstream sample was collected in April. Eight sediment samples were collected in September, four upstream and four downstream of the hydroelectric plant spillway.

Table 21  
SUMMARY OF INORGANIC PRIORITY POLLUTANT ANALYSES OF SEDIMENT AND WATER FROM THE  
FORD CANAL AND GREAT MIAMI RIVER (CASE NO. 1964 - SEPTEMBER 1983)  
CHEM-DYNE RI REPORT  
W65310.CO

Constituent <sup>a</sup>	Ford Canal - Sediment Samples								Great Miami River-Surface Water Samples			Ford Canal Sample
	FC-SED-1	FC-SED-2	FC-SED-3	FC-SED-4	FC-SED-7	FC-SED-8	FC-SED-9	FC-SED-10	GMR-001	GMR-002	GMR-003	GMR-101
Aluminum	6050	6750	5300	6450	1430	2560	8350	2740	701	970	923	937
Chromium	32.5	26	33.0	29.4	6.4	8.6	36.5	7.6	< 10	12	13	< 10
Barium	89.5	63	60.5	66.5	11.0	124	89	29.2	114	111	132	114
Beryllium	0.6	0.4	0.25	0.25	< 0.25	< 0.25	0.45	< 0.25	< 5	< 5	12	< 5
Cadmium	1.6	1.4	1.6	1.6	0.22	0.22	1.6	0.23	1.6	1.5	1.4	1.2
Cobalt	4.0	3.2	3.0	3.2	< 2.5	< 2.5	4.9	< 2.5	< 50	< 50	< 50	< 50
Copper	31.6	25.6	28.1	29.4	7.8	12.1	36.5	8.8	< 50	62	52	< 50
Iron	12700	9000	8950	8300	3550	5250	13300	4340	859	1370	1370	1320
Lead	43.4	26.9	23.8	325	4.1	35.4	59.5	10.8	< 5	14	9	11
Nickel	20.8	16.2	20.8	18.8	4.8	7.7	23.2	6.4	< 40	44	< 40	< 40
Manganese	379	181	202	178	137	199	297	157	75	90	90	89
Zinc	201	172	177	176	25.5	46.4	185	35.4	119	95	100	82
Boron	< 5	5.2	5.6	6.7	5.2	6.0	5.4	6.2	134	212	238	223
Vanadium	11.8	13.6	10.5	12.1	< 10	7.3	16.9	< 10	< 200	< 200	< 200	< 200
Arsenic	2.3	2.1	1.7	1.7	0.5	1.7	3.6	1.1	< 10	< 10	10	< 10
Antimony	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 20	< 20	< 20	< 20
Selenium	0.2	0.15	0.45	0.1	0.15	0.3	0.15	< 0.1	< 2	< 2	< 2	< 2
Thallium	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 0.5	< 10	< 10	< 10	< 10
Mercury	0.15	< 0.1	0.15	0.1	< 0.1	< 0.1	0.1	< 0.1	< 0.2	< 0.2	0.2	0.2
Tin	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 1	< 20	< 20	< 20	< 20
Silver	< 0.5	0.55	0.55	0.55	< 0.5	2.1	0.65	< 0.5	< 10	< 10	< 10	< 10
Cyanide	----- Spot test negative for these samples -----											

### Inorganic Analysis

Compared with the concentrations of elements determined in offsite soils which are considered representatives of "background" concentrations, the April sediment analysis did not show elevated concentrations of any elements.

The four upstream and four downstream sediment samples collected in September did not show a consistent pattern of increased downstream inorganic contamination for any element. Barium does occur in one downstream sediment sample at approximately twice the average upstream concentration of 70 ug/kg. However, barium concentrations in the remaining sediment samples were equal to or less than the upstream average.

### Organic Analysis

Organic contamination in the April sample consisted almost entirely of base/neutral polynuclear aromatic compounds (PNA's) and pesticides. Thirteen PNA's were identified in concentrations ranging from 0.20 to 2.2 mg/kg. Of these compounds, six are known animal carcinogens.

Four pesticides were also identified in the April sample. Endrin, aldrin, dieldrin and chlordane were determined with two column chromatography (method 608) at 0.97, 0.3, 0.18, and 3.8 mg/kg respectively. All of these pesticides are known to have been in the wastes stored at the sites.

Organic contamination in the eight September sediment samples were limited to two downstream samples, one from the mouth of the Ford Canal, and one from the north bank of the canal across from the April sample. Data from these samples are summarized on Table 22. In the first sample, only diethyl phthalate was identified. In the second sample, seven PNA compounds were identified at less than 600 ug/kg. These PNA compounds were among the thirteen compounds identified in the April sample. No pesticides were identified in any of the September sediment samples.

### FORD CANAL FISH

In September, fish tissue samples were collected in the Ford Hydraulic Canal in the downstream reach below the railroad bridge and the upstream reach immediately west of the diversion gate structure (approximately 3 miles upstream from the site).

Fish tissues consisted of fillets of carp, northern pike, largemouth bass, crappie, bluegill, and white bass. Also included were gizzard shad which were sent to the laboratory and analyzed as whole fish.

Table 22  
SUMMARY OF ORGANIC PRIORITY POLLUTANT ANALYSIS OF SEDIMENT AND WATER FROM THE FORD CANAL  
AND GREAT MIAMI RIVER (CASE NO. 1964 - SEPTEMBER 1983)  
CHEM-DYNE RI REPORT (W65310.CO)

Constituent <sup>a</sup>	Ford Canal - Sediment Samples (ug/kg)									Great Miami River (ug/l)			Ford Canal Sample (ug/l)	Field Blanks (ug/l)	
	FC-SED-1	FC-SED-2	FC-SED-3	FC-SED-4	FC-SED-7	FC-SED-8	FC-SED-9	FC-SED-10	FC-SED-99 <sup>b</sup>	GMR-001	GMR-002	GMR-003	GMR-101	GMR-501 <sup>c</sup>	GMR-502 <sup>d</sup>
<u>Acid Compounds</u>															
No priority pollutant acid compounds were identified.															
<u>Base/Neutral Compounds</u>															
Benzo(a)anthracene						260K									
Benzo(a)pyrene						260K									
3,4-benzo fluoranthene						410K									
Benzo(k)fluoranthene						410K									
Phenanthrene						250K									
Pyrene						600K									
Fluoranthene						580K									
Diethyl phthalate						260K									
<u>Volatile Compounds</u>															
1,1,1-trichloroethane											14	8K	40		
1,1-dichloroethene													5K		
Methylene chloride	69	46K	15K	35K		18K	27K	39K	38K	5K		5K	5K	5K	3,000

Pesticides

No priority pollutant pesticides were identified.

Nonpriority Pollutant

Hazardous Substances

Acetone

137K

<sup>a</sup> NA denotes that the compound was not analyzed for in this sample. Only compounds identified in samples are listed. Compounds not identified in any sample are not listed.

<sup>b</sup> Sediment field blank of diatomaceous earth.

<sup>c</sup> Laboratory water blank.

<sup>d</sup> Field blank.

Tissue purees were analyzed for percent lipids, priority pollutant base/neutral compounds pesticides, and PCB's.

The results of analysis are shown on Table 23 and can be summarized as follows:

- o priority pollutant pesticides were not identified in any sample of tissue at a detection limit of 1.0 ug/kg
- o PCB-1242 and PCB-1254 were identified in every fish tissue, both upstream and downstream specimens.
- o PCB concentrations in downstream compared to upstream fish tissues does not indicate higher contamination in downstream fish
- o Other base/neutral compounds included bis(2-ethyl hexyl), di-N-butyl and diethyl phthalates; isophorone was also identified. Upstream and downstream concentrations of base/neutral compounds were similar.

Total PCB concentrations determined in the Ford Canal fish tissues compared closely with PCB concentrations determined by others in the Great Miami River in the vicinity of the Ford Canal and up to 30 miles upstream from the canal.

#### GENERAL CONCLUSIONS AND OBSERVATIONS

General conclusions and observations regarding the water, sediment, and fish in the Ford Hydraulic Canal can be summarized as follows:

- o Direct contamination of the canal water as it passes the site is not demonstrated.
- o Downstream sediment on the southern bank of the canal near the storm sewer discharge is contaminated with low concentrations of PNA and possibly pesticide compounds. However, the contamination appears limited to the sediment between the N&WRR bridge and the Third Street bridge.
- o Analysis of fish tissue samples taken from the downstream canal area indicated no pesticide contamination. PCB's were determined in the tissue samples at concentrations similar to levels found in upstream tissue samples taken from the Great Miami River. Other base/neutral compounds identified included phthalates and isophorone.

Table 23  
SUMMARY OF FISH TISSUE ANALYSIS  
TOTAL PCB's AND PERCENT LIPIDS

<u>Fish Species</u>	<u>SAS Sample No.</u>	<u>Percent Lipids<sup>a</sup></u>	<u>Total PCB Concentration<sup>a</sup></u>
DOWNSTREAM FISH			
Northern Pike	736-E1	0.9	1326
Northern Pike	736-E2	1.1	1549
Large Mouth Bass	736-E3	3.6	2099
Large Mouth Bass	736-E4	3.6	2158
Large Mouth Bass	736-E5	3.0	1627
Carp	736-E6	7.0	2833
Carp	736-E7	1.7	1144
Carp	736-E8	4.8	3218
Carp	736-E9	13.2	7584
Carp	736-E10	9.6	3815
Gizzard Shad	736-E11	4.0	1829
Gizzard Shad	736-E12	4.2	3615
Gizzard Shad	736-E13	7.1	3369
Gizzard Shad	736-E14	3.4	1123
Gizzard Shad	736-E15	11.7	1817
Black Crappie	736-E16	3.4	180
Black Crappie	736-E17	2.1	1452
White Crappie	736-E18	3.7	1511
White Crappie	736-E19	4.3	1092
White Crappie	736-E20	1.2	827
Common Bluegill	736-E21	2.4	1170
Common Bluegill	736-E22	2.6	516
White Bass	736-E23	4.0	500
White Bass	736-E24	2.5	1169
UPSTREAM FISH			
Carp	736-E25	27.8	2132
Carp	736-E26	16.2	2804
Gizzard Shad	736-E27	12.3	3316
Gizzard Shad	736-E28	7.7	1356

<sup>a</sup>Concentration expressed as the sum of PCB 1242 and PCB 1254 in ug/kg.  
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## AIR

### HISTORICAL AIR QUALITY SITUATION

One of the initial causes for action at the Chem-Dyne site was public nuisance odors from waste handling operations. After Chem-Dyne operations were halted, large quantities of waste remained onsite and odors continued to be a problem although to a lesser degree.

Two air monitoring efforts have been conducted since 1982. Roy F. Weston, Inc. monitored ambient air in two 24-hour sampling periods in July-August during generator removals of waste sponsored by the receiver. The second air monitoring effort was performed by Pedco Environmental acting under O.H. Materials who performed the planned IRM waste removal during May through November 1983. The IRM air monitoring data reflects ambient conditions during the extensive waste removal operations.

Neither the Roy F. Weston, Inc. nor the Pedco data were evaluated for this report because the information is not applicable to the present site condition. All drummed and bulk wastes have been removed from the site. Wastes remaining at the site are in contaminated soil, groundwater, and onsite facilities.

### PRESENT AIR QUALITY SITUATION

Presently, attention has shifted to contamination in soil and onsite facilities as potential sources of air contamination. However, remedial action considered for the soil and facilities will also mitigate air problems caused by contaminated, wind-borne particulates (dust) and slow release of volatilizing organics.

### CONSIDERATIONS DURING REMEDIAL ACTIONS

Air quality will be a major consideration during implementation of source control remedial actions. Such actions may generate appreciable quantities of contaminated dust and increase the rate of organic compound volatilization. Specific modifications to typical construction practices will be required to minimize dust generation and control volatilization of exposed contaminants. Continuous air monitoring similar to the IRM procedures would be planned.

### SUMMARY OF CONCLUSIONS

- o Contamination of soil by inorganic and organic constituents appears greatest, in both frequency

and concentration, in surface or near surface soil (approximately the upper 10 feet).

- o All areas sampled within the fenced perimeter of the site and one area outside (soil test pit TP-2) indicated soil contamination by organic compounds.
- o The distribution of surface soil contamination by inorganic constituents appears erratic, potentially due to isolated contamination events.
- o Primary organic soil contaminants include pesticides, base/neutral compounds, and volatile organic compounds.
- o Mobilities of organic and inorganic contaminants are uncertain due to complex and unknown interactions among factors affecting mobility, such as organic and inorganic constituents present, concentrations of soil constituents, percent soil organic matter, percent clay, and microbial activity.
- o Chemical analysis of samples collected from the blue warehouse parking lot and potential spillage during waste drum storage in the blue warehouse requires redefinition of the site boundaries to include these areas in addition to the already fenced area.
- o The results of the aquifer pump test provided a range of values for transmissivity and storage coefficients, from  $0.3 \times 10^5$  gpd/ft to  $7 \times 10^5$  gpd/ft for transmissivity and 0.0009 to 0.32 for storage coefficients. Most of the values for transmissivity fall within a much narrower range of  $1 \times 10^5$  gpd/ft to  $3 \times 10^5$  gpd/ft. Higher values of transmissivity are generally toward the west and southwest.
- o Groundwater flow directions are across the site and downward from the area near well Nos. MW-1, MW-2, and MW-3 toward the west and southwest. Higher transmissivity values near the river and higher values of transmissivity parallel to the river may divert flow more toward the south. Conversely, strong vertical flow components and the impact of the Champion Paper Company's wells on the west side of the river indicate groundwater flow is moving to the west underneath the river. The direction of movement of the contaminated groundwater plume indicates westward and downward flow beneath the site and toward the Champion

wells is the predominant direction of flow. However, the lack of sampling points in the southwest area and in the deeper portions of the aquifer do not allow the alternate more southerly flow path to be evaluated in detail.

- o Rates of groundwater flow based on an assumed porosity (N) of 0.30, a gradient (I) of 0.002 and average hydraulic conductivity (K) of 1,100 gpd/ft<sup>2</sup> or 147 ft/day are:  $U = KI/N = 0.98 \text{ ft/day}$ . If the porosity and gradient are assumed to be relatively constant the greatest range of transmissivities provides for a range of groundwater velocities from 0.15 ft/day to 3.5 ft/day. Because of the limitations on the data from the pump test the upper and lower bounds for this range are suspect. The most reliable data indicate the range for groundwater velocities is between 0.5 ft/day to 1.5 ft/day.
- o The groundwater contamination plume is best defined by the extent of VOC's, many of which are relatively mobile and persistent. Within the plume, inorganics found in concentrations greater than Interim Primary Drinking Water Standards are barium, lead and mercury. The VOC plume has two distinct areas of very high concentrations relative to the overall plume. The apparent separation of the two areas of high concentration may be hydraulically induced (poor hydraulic connection) or may be related to separate sources of contamination.
- o Most of the VOC contamination appears to be in the upper 4 to 6 feet of the water table.
- o Locally VOC contamination has spread to depths of at least 65 feet in the aquifers.
- o Sample analysis demonstrated contamination of the Chem-Dyne buildings floor and contaminated seepage was observed in the basement of the boiler building. Reconnaissance, observations, and information concerning past waste handling practices at the site suggest potentially contaminated areas in the Ford building and the blue warehouse.
- o Direct contamination of the canal water as it passes the site is not demonstrated by the data.

- o Mercury concentrations were elevated in soil samples taken from southern portion of the site (soil test pits TP-1, TP-2, TP-3, and TP-4), Ford Canal sediment collected downstream from the site, and infrequently in apparently random groundwater samples.
- o Storm sewer infiltration discharges very low concentrations of endrin to the Ford Canal.
- o Hazards are presented by the extreme structural distress of some buildings, particularly the Chem-Dyne and boiler buildings. The relative ease of access to the building interiors compound these hazards.

### POTENTIAL ADDITIONAL STUDIES

Several conclusions from the RI analysis of field activities suggest that evaluation of remedial alternatives during the feasibility study may require additional data gathering and study. Potential additional studies may include:

- o Locating and sampling the sewer line and inverted siphon near monitoring well MW-15.
- o Sampling the ballast and soil in the railroad loading dock south of the Chem-Dyne building.
- o Additional study and sampling of onsite utilities.
- o Locating and sampling the suspected buried tanks east of the Ford building.
- o Sampling the interior of the blue warehouse, Ford building, and other onsite structures.
- o Further investigation of the blue warehouse parking lot and field south of it, to determine the extent of contamination (particularly under the parking lot).
- o Establish river stage gauge on the Great Miami River to allow refinement of aquifer and river interaction.
- o Further hydrogeologic study including additional monitoring well installation, simultaneous continuous recording of Great Miami River and groundwater levels, resampling of the Champion Paper wells, and sampling of the Mercy Hospital wells.

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